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Mr. James Saric
Remedial Project Manager
USEPA Region 5
77 West Jackson Boulevard
Mail Code: SR-6J
Chicago, IL 60605-3507

Date:
March 31, 2010

Contact:
Michael J. Erickson

Phone:
810.225.1924

Email:
michael.erickson@arcadis.com

Our ref:
B0064524

Subject:
Final Multi-Area Feasibility Study Technical Memoranda
Allied Paper, Inc./Portage Creek/Kalamazoo River Superfund Site

Dear Mr. Saric:

On behalf of the Kalamazoo River Study Group (KRSG), please find enclosed the final versions of two Multi-Area Feasibility Study Technical Memoranda – the *Preliminary Remedial Technology Screening* (Technology Screening Tech Memo) and the *Evaluation of Candidate Technologies and Testing Needs* (Technologies and Testing Needs Tech Memo).

These Tech Memos were originally submitted in February 2008 to satisfy the requirements of Task 1.2.2 of the Statement of Work (SOW) attached to the Administrative Settlement Agreement and Order on Consent (AOC) for the Allied Paper, Inc./Portage Creek/Kalamazoo River Superfund Site (Comprehensive Environmental Response, Compensation, and Liability Act [CERCLA] Docket No. V-W-07-C-864). KRSG revised and resubmitted both Tech Memos in January 2010 in response to U.S. Environmental Protection Agency (USEPA) comments, and USEPA approved those versions on March 24, 2010.

If you have any questions, please do not hesitate to contact us.

Sincerely,

ARCADIS

Michael J. Erickson, P.E.
Associate Vice President

Enclosures: James Saric (two hard copies)

Copies:
Jeff Keiser, CH2M HILL (one hard copy)
Paul Bucholtz, MDEQ (two hard copies)
Garry Griffith, P.E., Georgia-Pacific LLC
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Mark P. Brown, Ph.D., Waterviews LLC
Richard Gay, Weyerhaeuser Company
Martin Lebo, Weyerhaeuser Company
Kathy Huibregtse, RMT, Inc.
Stephen Garbaciak Jr., P.E., ARCADIS

Allied Paper, Inc./Portage Creek/Kalamazoo River Superfund Site

Multi-Area Feasibility Study Technical Memorandum:

Preliminary Remedial Technology Screening

Kalamazoo River Study Group

March 2010

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 5
77 WEST JACKSON BOULEVARD
CHICAGO, IL 60604-3590

REPLY TO THE ATTENTION OF:

March 24, 2010

SR-6J

Mr. Michael J. Erickson
Associate Vice President/Principal Engineer
ARCADIS
10559 Citation Drive, Suite 100
Brighton, MI 48116

RE: Multi-Area Feasibility Study Technical Memorandum: Preliminary Remedial Technology Screening

Dear Mr. Erickson:

The United States Environmental Protection Agency (EPA) has completed its review of the January 2010 final Multi-Area Feasibility Study Technical Memorandum: Preliminary Remedial Technology Screening for the Allied Paper, Inc./Portage Creek/Kalamazoo River Superfund Site.

This technical memorandum has adequately addressed EPA's previous comments and incorporated them into the document. Therefore, EPA approves the final evaluation of preliminary remedial technologies memorandum.

Please contact me at (312) 886-0992 if you have any questions regarding this matter.

Sincerely,

James A. Saric
Remedial Project Manager
SFD Remedial Response Branch #1

cc: Paul Bucholtz, MDEQ
Gary Griffith, Georgia-Pacific
Richard Gay, Weyerhaeuser

Allied Paper, Inc./Portage Creek/
Kalamazoo River Superfund Site

Supplemental Remedial Investigations/
Feasibility Studies

Multi-Area Feasibility Study Technical Memorandum:

Preliminary Remedial Technology Screening

Kalamazoo River Study Group

March 2010

ARCADIS

Michael J. Erickson, P.E.
SRI/FS Project Coordinator

Stephen Garbaciak Jr., P.E.
Vice President

Multi-Area Feasibility Study Technical Memorandum:

Preliminary Remedial Technology Screening

Allied Paper, Inc./Portage Creek/
Kalamazoo River Superfund Site

Supplemental Remedial Investigations/Feasibility Studies

Prepared for:

Kalamazoo River Study Group

Prepared by:

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Date:

March 2010

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Tables

Figure

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Acronyms and Abbreviations

ARCS	Assessment and Remediation of Contaminated Sediments
AOC	Administrative Settlement Agreement and Order on Consent
ARAR	Applicable or Relevant and Appropriate Requirement
CAD	Confined aquatic disposal
CDF	Confined disposal facility
CERCLA	Comprehensive Environmental Response, Compensation, and Recovery Act
CICEET	Cooperative Institute for Coastal and Estuarine Environmental Technology
CSM	Conceptual Site Model
ERAs	Ecological Risk Assessments
FS	Feasibility Study
GRAs	General Response Actions
HHRAs	Human Health Risk Assessments
KRSG	Kalamazoo River Study Group
mg/kg	milligrams per kilogram
MNR	Monitored natural recovery
NCP	National Contingency Plan
OU5	Operable Unit 5
PCBs	polychlorinated biphenyls
RAOs	Remedial Action Objectives
RCC	Resources Conservation Company
SOW	Statement of Work
SRI	Supplemental Remedial Investigation
TCRA	Time-Critical Removal Action
TSCA	Toxic Substances Control Act
USEPA	United States Environmental Protection Agency
ZVI	Zero-valent Iron

1. Introduction

On February 21, 2007 Georgia-Pacific Corporation and Millennium Holdings, LLC—collectively referred to as the Kalamazoo River Study Group, or KRSG—voluntarily entered into an Administrative Settlement Agreement and Order on Consent (AOC) with the U.S. Environmental Protection Agency (USEPA) that will govern the majority of work from this point forward at the Allied Paper, Inc./Portage Creek/Kalamazoo River Superfund Site (Site or Superfund Site), located in Kalamazoo and Allegan counties in southwest Michigan (Figure 1). The AOC describes a series of activities associated with supplemental remedial investigations and feasibility studies (SRIs/FSs) that will be carried out over the next several years in Operable Unit 5 (OU5) of the Site (SRI/FS AOC; Comprehensive Environmental Response, Compensation, and Liability Act [CERCLA] Docket No. V-W-07-C-864; USEPA 2007a). OU5 encompasses 80 miles of the Kalamazoo River from Morrow Dam to Lake Michigan, including a stretch of Portage Creek from Alcott Street to its confluence with the Kalamazoo River.

The Statement of Work (SOW) included as Attachment A to the SRI/FS AOC specifies supplemental remedial investigations and feasibility studies to address polychlorinated biphenyls (PCBs) in seven Areas of OU5. The seven Areas in OU5 are shown in Figure 1.

1.1 Multi-Area Feasibility Study Documents

As described in the SOW, Area-specific feasibility studies (FSs) will be developed to support Area-specific risk management. The various FS activities that will be implemented by the KRSG will include examining potential general response actions and evaluating remedial technologies and alternatives to address impacts to human health and the environment using a risk-management approach consistent with the *Contaminated Sediment Remediation Guidance for Hazardous Waste Sites* (USEPA 2005). The FS development activities will also be performed consistent with the *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA* (USEPA 1988a) and *CERCLA Compliance with Other Laws Manual, Parts I and II* (USEPA 1988b; USEPA 1989a).

To guide the FS work and provide for consistency and efficiency across the seven Areas of OU5, the SOW specifies preparation of several Multi-Area FS Planning Documents as the first step in the development of the FS reports. Per the SOW, these Multi- Area FS Planning Documents are intended to “set forth general approaches and concepts with the intent of streamlining preparation of work plans and minimizing review times for future deliverables” (USEPA 2007a). An additional intention is to promote a consistent approach for completion of SRI/FS activities in each Area of the Site, as appropriate. The Area-specific work plans will incorporate the Multi-Area documents by reference, with appropriate Area-specific modifications. Area-specific modifications may incorporate potential new information on expected land use, potential advances in remedial technology, information from new studies, or other information.

The four Multi-Area FS Planning Documents developed for the Site are described below.

- **Preliminary Remedial Technology Screening** – This is the subject described in this technical memorandum, and includes identifying general response actions and a preliminary list of remedial technologies to address contaminated soil, sediments, and groundwater in each Area.

- **Preliminary List of Possible Applicable or Relevant and Appropriate Requirements** – The second FS Planning Document identifies a preliminary list of possible state and federal applicable or relevant and appropriate requirements (ARARs), including chemical-specific, location-specific, and action-specific ARARs as appropriate. This preliminary list of possible ARARs may apply to the circumstances and array of potential remedies at one or more Areas.

- **Preliminary Permitting/Equivalency Requirements** – The third FS Planning Document provides a preliminary analysis of likely permit or permit equivalency requirements. The preliminary analysis focuses on substantive requirements of permits that may be applicable across the Site, and includes a discussion of potential waivers, as appropriate.

- **Candidate Technologies and Testing Needs** – The fourth FS Planning Document identifies a series of candidate technologies for a treatability studies program that, per Section 4.1 of the SOW, will cover the "range of technologies required for alternative analysis." This memorandum includes a compilation of literature information on the performance, relative costs, applicability, removal efficiencies, operation and maintenance requirements, and implementability of candidate technologies.

These Multi-Area FS Planning Documents were developed based on the understanding that the primary constituent of concern at the Site is polychlorinated biphenyls (PCBs) and the relevant contaminated media are in-stream sediment, bank soil, and floodplain soil. The candidate technologies and process options evaluated in these planning documents do not include approaches specific to groundwater. If groundwater is identified as a medium of concern in a specific Area, appropriate technologies and process options will be evaluated in that Area-specific FS Report.

1.2 Document Overview

This Multi-Area FS Planning Document, *Preliminary Remedial Technology Screening*, identifies preliminary General Response Actions (GRAs) and a preliminary list of remedial technologies to address contaminated soil and sediments at each Area.

Section 2 presents a summary of the *Generalized Conceptual Site Model* (Generalized CSM; ARCADIS 2009) and preliminary GRAs that may be applicable across the seven Areas of OU5.

Section 3 presents, discusses, and screens technologies and process options that could potentially be implemented to achieve the GRAs, as appropriate, in one or more Areas of OU5.

Section 4 provides a list of references cited in this document.

2. Development of General Response Actions

This section presents possible GRAs that may apply to the circumstances and array of potential remedies in one or more Areas of OU5. For the purpose of the Multi-Area FS Planning Documents, possible GRAs have been developed to address potential exposure pathways associated with Site-related contaminants identified in the Generalized CSM (ARCADIS 2009). The Generalized CSM is summarized below, followed by a description of the process used to develop the possible GRAs.

2.1 Summary of Generalized Conceptual Site Model

The Kalamazoo River between the City of Kalamazoo and the Lake Allegan Dam is a series of free-running river reaches interrupted by seven dams constructed for hydropower generation or other purposes. Morrow Dam – located at the upstream end of the Site – and Lake Allegan (Calkins) Dam are currently used for hydroelectric power generation, while the other dams have been partially removed and the historical impoundments drawn down. The Plainwell No. 2, Plainwell, Otsego, Trowbridge, and Allegan City Dams were previously used for power generation or mill service. The Otsego City Dam was used for transportation purposes and was at one time served by a lock. Downstream of Lake Allegan, the river flows unimpeded through relatively undisturbed wetlands and ancient coastal plains of Lake Michigan to its mouth at Saugatuck, Michigan. Sediments in the Kalamazoo River, in particular within the impounded or historically-impounded areas, contain varying levels of PCBs, which are the primary constituent of concern at the Site.

Data collected at the Site over the past 15 years indicate that potential risks to human and ecological receptors are primarily associated with consumption of PCB-containing fish tissue, although other exposure pathways exist.

The nature and extent of PCB contamination at the Site and associated fate and transport mechanisms are generally understood and defined by the existing data and observations, as well as analysis derived from those data. In general, sediment and floodplain soil PCB concentrations between Morrow Dam and Lake Allegan vary in accordance with depositional histories in formerly impounded areas, and with variations in sedimentation patterns in the river channel. Higher concentrations are found in localized areas, particularly within historically submerged sediments in the former impoundments that were exposed when water levels in the impoundments were lowered. Although the highest PCB concentrations are found in the former impoundments, the majority (77%) of the PCB mass in river sediments occurs in Lake Allegan. The majority of the PCBs in Lake Allegan are located below the bioavailable zone of surface sediment. Downstream of Lake Allegan Dam, sediment and floodplain soil PCB concentrations are lower and less variable. PCB transport data for the Kalamazoo River show that Lake Allegan continues to act as a sediment trap and as a net sink for PCB; however, PCB transport over Lake Allegan Dam continues.

The PCB-containing in-stream sediments and the erodible bank materials in formerly impounded areas are the primary continuing sources of PCBs to the river. The Time-Critical Removal Actions (TCRA) completed and currently underway in the former Plainwell Impoundment and Plainwell Dam No. 2 Area, respectively, were designed to address PCB-containing bank soil and near-shore and mid-channel sediment. Extensive source control activities have also been completed at several of the landfill operable units within the Site and certain former mill properties, as summarized in the Generalized CSM (ARCADIS 2009).

PCB concentrations in fish at the Site have declined over time in most areas, and PCB concentrations in surface water and sediment have also declined. Source control activities and natural processes, including sediment deposition, have contributed to reduced PCB bioavailability. The primary continuing source of PCBs to the river system (and ultimately fish) is the PCB-containing exposed sediments within the former impoundments, which re-enter the river through bank soil erosion. In addition, there are other more difficult to quantify PCB sources, including, but not limited to, non-point sources such as atmospheric deposition, stormwater runoff, and PCBs that enter the Site from Morrow Lake.

Findings presented in prior risk assessments provide a basis for the current understanding of exposure media, pathways, and receptors for the Site. They are summarized as follows:

- Exposure Media – includes in-stream sediment, surface water, bank soil, and floodplain soil (including formerly submerged sediments that are now exposed in the floodplain)

- Exposure Pathways – includes consumption of biota (e.g., fish); direct contact, consisting of uptake, ingestion, dermal contact; and inhalation (for human receptors)

- Receptors – includes ecological receptors (aquatic and terrestrial) and human receptors (anglers, recreationalists, and residents)

Results from ecological and human health risk assessments prepared for the Site will be used to refine Area-specific CSMs and possible GRAs.

2.2 Possible General Response Actions

Consistent with the USEPA's RI/FS Guidance (USEPA 1988a), it is anticipated that achieving the remedial action objectives (RAOs)—which typically are contaminant- and medium-specific goals for protecting human health and the environment—that will be included in Area-specific FS Reports will require addressing Site-related sources of PCBs and the potential PCB exposure pathways for human and ecological receptors.

2.2.1 Possible General Response Actions for In-stream Sediment, Bank Soil, and Floodplain Soil

Using existing Site characterization data, a series of medium-specific (e.g., in-stream sediment) GRAs to satisfy likely RAOs has been identified as the basis for the preliminary screening of remedial technologies included in Section 3 of this technical memorandum. The possible GRAs and the implementing technologies described in this document were developed consistent with guidance included in USEPA's *Principles for Managing Contaminated Sediment Risks at Hazardous Waste Sites* (Sediment Remediation Guidance; USEPA 2005).

Each of the three major sediment remediation approaches (dredging, capping, and monitored natural recovery [MNR]) identified in the Sediment Remediation Guidance (USEPA 2005) were included as possible GRAs and evaluated for the Site. Table 1 presents the possible GRAs and associated technologies applicable to each medium of interest (i.e., in-stream sediment, bank soil, and floodplain soil).

2.2.2 Possible General Response Actions for Groundwater

Four quarters of groundwater sampling data have been collected from wells installed in the former Plainwell Impoundment area (as described in the USEPA-approved *Former Plainwell Impoundment Time-Critical Removal Action Design Report* [TCRA Design Report; ARCADIS BBL 2007a] and the *Supplemental Remedial Investigation/Feasibility Study Work Plan – Morrow Dam to Plainwell Dam* [Area 1 SRI/FS Work Plan; ARCADIS BBL 2007b]). Results – including Agency split samples – have all been non-detect for PCBs (Garbaciak 2009). Additional groundwater data are being collected; however, all results to date indicate that groundwater is not a medium of concern for OU5. The candidate technologies and process options evaluated in these planning documents therefore do not include approaches specific to groundwater. If groundwater is identified as a medium of concern in a specific Area, relevant technologies and process options would be evaluated in that Area-specific FS Report.

A wide range of groundwater remediation technologies are available (USEPA 2007b) that may be applicable to the Site. Possible GRAs that may be applicable to addressing potential groundwater impacts at the Site are provided below:

- No action
- Engineering/institutional control (e.g., restrictions on groundwater use for potable purposes)
- Monitored natural recovery (e.g., utilizing ongoing biodegradation)
- Source control
  - Removal (e.g., removal of PCB-containing floodplain soil)
  - Stabilization (e.g., capping of PCB-containing floodplain soil to reduce infiltration to groundwater)
  - Isolation (e.g., barrier wall to mitigate groundwater migration)
- Upgradient flow diversion to reduce flow through source areas
  - Plantings for phyto-transpiration to lower groundwater table
  - Groundwater extraction to lower groundwater table
  - Upgradient barrier walls to redirect flow
- Passive treatment wall or permeable reactive barrier along the river (e.g., hydraulic cutoff wall, permeable reactive barrier, or other)
- Extraction of PCB-containing groundwater and treatment prior to discharge
- Interception trench or wells down-gradient coupled with extraction and treatment

While possible GRAs for groundwater have been identified, insufficient data exists upon which to base any detailed screening of technologies or process options for PCBs in groundwater in OU5. Any evaluation and screening of technologies and associated process options that may be needed to address potential risks associated with PCBs in groundwater will be performed during the Area-specific FS activities.

2.2.3 Other Considerations in the GRAs and Preliminary Technology Screening

Remedial activities, such as material handling and treatment associated with the implementation of the GRAs identified in Table 1, are also presented. Candidate technologies for implementing the remedial activities are identified and screened in a separate Multi-Area FS Planning Document titled *Evaluation of Candidate Technologies and Testing Needs* (ARCADIS 2010).

The extent to which remedial action may or may not be required for each medium in each of the different Areas will be addressed through Area-specific SRI/FS activities. The development of the possible GRAs and subsequent screening and evaluation of the technology and process options for each Area will be an iterative process, starting from the preliminary screening established here and incorporating Area-specific considerations to allow necessary adjustments based on refining the generalized CSM and current exposure assumptions.

3. Preliminary Remedial Technologies and Process Options Screening

3.1 General

This section presents a preliminary identification, with supporting justification, of the technologies and process options that may be studied in the Area-specific FSs. The primary justification for selecting the preliminary suite of remedial technologies and process options presented in this technical memorandum is their potential capability to address ongoing sources of PCBs and contribute to the achievement of relevant risk management-based cleanup goals that may be established in each Area of the Site. Approaches will likely be focused on the key environmental media of interest – in-stream sediment, bank soil, and floodplain soil – but remedial technologies specific to groundwater may also be evaluated during the Area-specific FS process, if appropriate, pending further investigation. The detailed technology screening and screening of associated technology process options for any GRAs identified for groundwater will be performed during the Area-specific FS process.

Possible GRAs for in-stream sediment, bank soil, and floodplain soil include general categories of technology types (for example, dredging is a technology type) that may include one or more process options that could be applied at the Site (for example mechanical dredging in the wet, mechanical removal in the dry, or hydraulic dredging are all dredging process options). GRA types and their associated remedial technologies and process options have been identified for the three media of interest (in-stream sediment, bank soil, and floodplain soil) in addition to excavated or dredged material as a fourth “medium” of interest. In addition, technologies and process options that could be applied to manage excavated or dredged material after removal have been identified. To identify appropriate alternatives in this preliminary screening, a two-step screening process was employed for each GRA type, as described below.

The first step is a preliminary screening of technologies. This generally consists of a technical implementability evaluation of existing technologies to eliminate those technologies that are not appropriate based on the current understanding of Site conditions, the chemical/physical characteristics of the media of interest, or that have not been successfully applied on a full-scale basis at other PCB-impacted sites. The second step is a preliminary screening of process options associated with the remedial technologies retained as a result of the first step. These screening steps are performed by applying general knowledge and experience gained at this and other sites, using information available in the literature and professional judgment.

The following sections describe the identification and two-step screening process conducted for the technologies and process options to address PCBs in sediment, bank soil, and floodplain soil at the Site, as well as those considered to address excavated or dredged sediments and/or soils. For those technologies that have multiple process options and were subject to a preliminary process option screening, a separate subsection is included to present the screening results for the individual process options to identify those that have been retained for further evaluation in the Area-specific FS Reports.

3.2 In-Stream Sediments

To address PCBs in the in-stream sediments at the Site, the following GRAs were considered, and their associated technologies were screened:

- No action
- Engineering/institutional controls
- MNR
- *In situ* containment
- Removal
- *In situ* treatment

Each of these possible GRAs is described briefly below, followed by a discussion of the preliminary screening of technologies. The results of the preliminary screening of technologies are summarized in Table 1. The associated technology process options were further evaluated and screened for those technologies that were retained after the preliminary screening. The results of the preliminary process option screening are presented in Table 2.

3.2.1 No Action

The “no action” GRA would not include any active or passive remediation. While conditions are likely to change over time as natural attenuation of PCBs in sediments occurs, the no action GRA would not include any long-term monitoring or related efforts to track changes or enhance the rate of change. The National Oil and Hazardous Substances Pollution Contingency Plan (NCP) requires that a “no action” alternative be considered at every site (40 CFR 300.430[e][6]). Thus, this alternative was retained in the preliminary screening of technologies and process options.

"No action" is clearly appropriate in areas of a site that already meet cleanup goals, and thus can be a component of a selected remedy. The "no action" GRA is implementable and would provide a baseline against which other alternatives can be assessed in the Area-specific FSs. For these reasons, and in accordance with the NCP, the "no action" alternative has been retained for evaluation in the Area-specific FSs.

3.2.2 Engineering/Institutional Controls

Engineering/institutional controls are physical, legal, and/or administrative controls that would be implemented to limit potential exposure to PCBs in sediment**.** These controls can be used, alone or in combination, to restrict access to portions of the Site and/or to initiate and maintain appropriate uses that mitigate the potential for future exposure to PCBs during and after remedy implementation. Engineering/institutional controls to address in-stream sediment can include access restrictions (such as fences and signs), activity restrictions on fishing and hunting (such as catch-and-release fishing restrictions and/or restrictions on certain types of waterfowl hunting), dredging moratoria, information devices (such as biota consumption advisories), and pool elevation control in existing impounded areas. If pool elevation control measures are incorporated into a remedy for a particular Area, maintenance of the dam in question would be required to verify the dam continues to function as intended. The feasibility of dam maintenance arrangements would be evaluated in Area-specific FS Reports, as relevant and appropriate.

Engineering/institutional controls can be used at all stages of the remedial process to mitigate the potential for exposure to contaminated sediments. They are often used in conjunction with other GRAs (e.g., MNR, sediment removal, *in situ* containment) both during and following remedy implementation. Engineering/institutional controls (i.e., fish consumption advisories) are already in place at the Site. At other contaminated sediment sites including the Housatonic River (MA), Spokane River (WA), the Sheboygan River (WI), and the Ottawa River (OH), catch-and-release programs and/or fish advisories are in place to help mitigate exposure through human consumption of PCBs in biota. Thus, engineering/institutional controls were retained for the preliminary process option screening.

3.2.3 Monitored Natural Recovery

Monitored natural recovery is a GRA that relies on ongoing, naturally occurring processes to contain, destroy, or otherwise reduce the bioavailability or toxicity of chemical constituents in sediment, with monitoring to assess the rate and degree of recovery or attenuation. Water bodies have a considerable inherent capacity to recover from either natural or human disturbances. As described in Brown (1999), Larson (1993) documented the recovery of Spirit

Lake – the largest lake in the blast zone of Mount St. Helens when it erupted in 1980 – from a "biological desert" to a "revitalized system" that was comparable to pre-blast conditions in just six years. DeVault et al. (1996) reviewed PCB and DDT data for lake trout in the Great Lakes, and between 1977 and 1992, concentrations were reduced by half every four to eight years.

The rate and success of natural recovery is typically linked to the effectiveness of upstream source control, which is necessary to prevent or minimize the continuing contribution of active sources of contaminants to the water body. The natural processes relied upon for MNR may involve multiple physical, biological, and chemical processes that act together to reduce the mass, toxicity, mobility, concentration, or availability of contaminants in the sediment, as described below:

- **Physical processes** promote natural attenuation in sediments through mechanisms that may bury, mix, dilute, or transfer contaminants to another medium (USEPA 2005). One such process is sedimentation, which can eliminate or reduce exposure and risk by containing the contaminants in place through the deposition of cleaner sediments on top of impacted sediments. The cleaner sediments mix with and effectively reduce constituent concentrations in the upper layer of the sediments, which is the point of exposure for most receptors. Long-term stability provided by sedimentation may be affected by natural events such as floods or ice scouring; therefore, these events must be considered at sites where MNR is a remedial option. Other physical attenuation processes include erosion, dispersion, dilution, bioturbation, advection, and volatilization, which may contribute to the transfer of PCBs to another medium or to their continued movement within the Site. These processes may reduce or transfer the risks posed by the PCBs and therefore may be applicable mechanisms for MNR depending on the potential for increased exposure.

- **Biological processes**, like physical processes, depend on site conditions and are therefore highly variable. Although rates of biodegradation are typically driven by nutrient availability, the mechanism of degradation is determined by the oxidation-reduction conditions of the sediment and the nature of the microbiological community (Atlas et al. 1981). With regard to PCBs, USEPA has noted that little evidence exists to suggest that dechlorination occurs to a significant extent under the anaerobic or anoxic conditions that are typically found in most sediment (USEPA 2005).

- **Chemical processes,** such as the sorption of PCBs to the organic carbon materials in soils and sediments, can control the mobility and bioavailability of PCBs and thus affect rates of attenuation.

Natural recovery may also be enhanced by certain active remedial actions. One option is placing engineered structures in a waterway to slow down surface water velocities and thus improve conditions for sediment deposition (enhanced sedimentation). Another method involves placing a thin layer of clean material over contaminated sediments to accelerate the natural recovery process (thin-layer placement).

Certain MNR and enhanced MNR approaches have been demonstrated at aquatic sites with PCB-containing sediment (USEPA 2004a). These approaches can be and have been applied alone or in combination with other, more active remedial technologies/process options (e.g., removal, *in situ* containment). MNR has been selected as a component of the remedy for contaminated sediment at approximately one dozen Superfund sites (USEPA 2005). Certain areas of the Site may be more amenable to MNR than others; these include areas that are more depositional in nature and where geochronologic analysis of finely sectioned sediment cores and related information indicates continuing deposition is reducing PCB bioavailability over time in a predictable manner. MNR may also be suitable for areas where PCB concentrations are already low and which may recover further following upstream source control and/or remediation. Thus, MNR and enhanced MNR (with thin-layer placement) were retained for the preliminary process option screening.

3.2.4 *In Situ* Containment

This GRA includes the active placement of clean cover materials over impacted sediments to mitigate the potential for exposure to human and ecological receptors. *In situ* containment technologies that have been implemented at other sites to mitigate exposure to in-river sediments include capping and river rechannelization. Capping involves placing material (e.g., clean sand, gravel, cobbles, sorbents, geofabrics, or geocomposites [e.g., Aquablok™]) over sediment to isolate constituents of concern from biota, to mitigate chemical flux, and/or to minimize erosion potential. Rechannelization involves the complete backfilling of a portion of the river channel and redirecting all or a portion of the river flow into a newly constructed or modified river channel. Both process options are described in more detail below.

- **Capping** is an active remediation option in which a layer of clean material is placed on top of impacted sediment to contain and stabilize the PCB-containing sediment and to sequester those sediments from the biologically active zone within the sediment bed and the overlying water column. Caps may be constructed of clean sediment, sand, gravel, and/or amended material, or may, if necessary, involve a more complex design using geotextiles, liners, geocomposites, and sorbent materials. A cap is generally designed to reduce risk through: 1) physical isolation of the impacted sediment sufficient to reduce exposure due to direct contact and to reduce the ability of burrowing organisms to move contaminants to the cap surface, 2) stabilization of contaminated sediment and erosion protection of the sediment and cap sufficient to reduce resuspension and transport of contaminants into the water column, and/or 3) chemical isolation of contaminated sediment sufficient to reduce exposure from dissolved contaminants that may be transported into the water column (USEPA 2005).

- **Rechannelization** involves permanently redirecting a waterway into a newly constructed or modified channel and covering/isolating the material in the original channel (or a portion of it) in place. Ideally, the soil excavated to construct the new channel may be used to backfill the existing reach which is being diverted. Rechannelization could only be implemented in those areas of the Site where the adjacent property is available and the local topography would not be restrictive.

As described in USEPA (2005), capping is a viable approach for remediating impacted sediments. *In situ* capping of sediments has been applied in a variety of settings including rivers, near-shore areas, and estuaries. Historically, a variety of capping materials and cap placement techniques have been used, and monitoring data collected for a number of projects indicate that capping can be an effective remedy (Fredette et al. 1992; Brannon and Poindexter-Rollings 1990; Sumeri et al. 1994). Conventional marine construction equipment and techniques can be used for capping projects, or equipment may be modified for specific applications (as in the case of low-impact placement). While caps have been effectively used as a stand-alone remedy (e.g., Denny Way, WA and Eagle Harbor, WA [Palermo et al. 1998; Bailey and Palermo 2005]), they have also been incorporated in recent years into multi-component approaches—caps have been used in conjunction with removal (part of a site capped, part dredged) or placed over previously dredged areas to provide isolation of residual sediments. Caps or residual cover material have been constructed and/or are being designed as part of the selected remedy at a number of sediment sites containing PCBs including the Housatonic River (MA), the St. Lawrence River (NY), Onondaga Lake (NY), Eagle Harbor (WA), Hudson River (NY), and Fox River (WI). Capping may likewise be an appropriate remedy or remedy component for certain stretches of the Site. For those reaches with shallow water, cobbly bottom, and relatively high surface water velocities during high flow events, sediment removal may enable placement of a cap by achieving post-placement cap elevations that are not overly restrictive to river flow or navigation. In other areas (e.g., deeper, lower-energy areas), capping may be employed without prior removal when the magnitude of potential impacts to flow velocities, water levels, and/or navigable depth is small or acceptable (www.sediments.org/capping-chart.html).

River rechannelization has been successfully applied at a number of sediment sites to mitigate the potential for exposure to chemical constituents in sediment by humans and ecological receptors, including the Unnamed Tributary (OH) and the Moss-American Superfund Site (WI). At the Unnamed Tributary site, sediments were first dredged using mechanical equipment in the dry, and the Tributary was subsequently backfilled with soil generated during construction of a new channel to prevent contact of stormwater or river water with residual PCBs present following dredging (BBL 2000). At the Moss-American Superfund Site in Milwaukee, WI, rechannelization of approximately 6 miles of the Little Menomonee River was selected as the final remedy to address creosote impacts to the river (USEPA 2006a). There are some areas of the Site where the broad adjoining floodplains and configuration of the Kalamazoo River channel could potentially support rechannelization.

Given their successful full-scale use at other PCB-impacted sites, and the presence of site conditions in various reaches of the Kalamazoo River that are potentially conducive to capping and/or rechannelization, both options were retained for further evaluation in the preliminary process option screening step.

3.2.5 Removal

Removal involves the physical removal of PCB-containing sediments via excavation or dredging. Removal may involve open dredge bucket operations, closed environmental dredge bucket operations and/or various operational controls on dredging activities to reduce environmental impacts. Environmental dredging is intended to remove sediment impacted above certain action levels while minimizing the spread of contaminants to the surrounding environment during dredging (National Research Council 1997). Dredging may be performed using mechanical techniques, either through mechanical excavation in the dry (i.e., after isolating and dewatering the removal area), mechanical dredging in the wet (i.e., through the water column), and/or using hydraulic dredging techniques. The selection of the appropriate technique depends on factors such as accessibility, water depth, hydrology, sediment composition, debris content, and the subsequent treatment/disposal options.

Due to the well-established limitations on effectiveness of removal technologies, post-removal residual contaminant levels may require additional management in some cases. Residuals management by placement of cover materials over dredged areas to dilute or cover residual concentrations of contaminants has been used for some environmental dredging projects (National Research Council 2007). Residual cover layers may also be placed in conjunction with placing backfill in the dredged area to restore pre-dredging bottom elevations where necessary.

Removing sediment by mechanical and/or hydraulic dredging has been implemented at numerous PCB-impacted sediment sites on a full-scale basis. Accordingly, sediment removal, including mechanical dredging in the wet, mechanical excavation in the dry, and hydraulic dredging, was retained for the preliminary process option screening.

3.2.6 *In Situ* Treatment

In situ treatment involves using physical, chemical, or biological processes to destroy or degrade contaminants or to immobilize the contaminants in place within the sediment (Chambers 1991, Renholds 1998). Each of these process options is discussed below.

- ***In situ* physical treatment** involves injecting and/or mixing an immobilization agent into the sediment to reduce the mobility of PCBs in the sediment. The agent can be coal, coke breeze, activated carbon, Portland cement, fly ash, limestone, or another additive. It is injected/mixed into the sediment to encapsulate the contaminants in a solid matrix and/or chemically alter the contaminants by converting them into a less bioavailable, less mobile, or less toxic form.

- ***In situ* chemical treatment** involves injecting chemical surfactants/solvents or oxidants into the treatment area to remove or destroy PCB constituents. Chemical treatment processes may include common or proprietary solvents and other liquids.

- ***In situ* biological treatment** involves introducing microorganisms and/or nutrients into the treatment zone to increase ongoing biodegradation rates of PCBs in sediments. Biodegradation of PCBs may occur either in the absence of oxygen (anaerobic conditions) in a process termed dechlorination, or in the presence of oxygen (aerobic conditions).

In situ treatment methods for sediments are currently under development, with few methods available commercially or proven beyond the bench or pilot scale. USEPA has noted that “significant technical limitations currently exist for many of the treatment technologies,” especially in terms of their effectiveness (USEPA 2005). The efficiency for *in situ* treatment is summarized as “almost always less than *ex situ* treatment” (Renholds 1998). Each of the *in situ* treatment process options is discussed below.

In situ physical treatment was not retained for the preliminary process option screening because the process has not yet been sufficiently developed for remediating contaminated sediments, nor has it been successfully implemented at full scale for PCBs. General disadvantages noted for *in situ* physical treatment (solidification/stabilization) focus on the lack of process controls, particularly with mixing conditions and curing temperatures encountered with in-place sediments (Kita and Kubo 1983). For example, at an *in situ* demonstration project performed on sediments in the Manitowoc River (WI) containing PAHs and several heavy metals from a former coal gasification plant, good controls could not be established on the mixing of cement/fly ash slurry with the sediment (Renholds 1998). The lack of adequate process controls has relegated the use of this technique to instances when the contaminated sediment can be isolated from the water body (Board on Environmental Studies and Toxicology 2001). USEPA's *Contaminated Sediment Remediation Guidance for Hazardous Waste Sites* (USEPA 2005) points out that "the lack of an effective delivery system has hindered the application of *in situ* stabilization systems."

In situ chemical treatment was not retained for the preliminary process option screening because it also has not been successfully demonstrated at full scale for PCBs in sediment. *In situ* chemical remediation is often based on the addition of an oxidant to the sediment. Studies have shown that the elevated biological oxygen demand exhibited by most sediments requires more oxidant than expected (Murphy et al. 1995). USEPA's *Contaminated Sediment Remediation Guidance for Hazardous Waste Sites* (USEPA 2005) states that "most techniques for *in situ* treatment of sediments are in the early stages of development…" Developing an effective *in situ* delivery and homogenization system for reagents has been problematic. Current studies are underway at the Cooperative Institute for Coastal and Estuarine Environmental Technology (CICEET) for an *in situ* sediment ozonator that may eventually have the potential to remediate PCBs *in situ*, but at this time, the project remains in the research stages and has not been applied at the full scale (Hong and Hayes 2006). Dr. Kevin Gardner of the University of New Hampshire is currently carrying out studies on *in situ* dechlorination of PCBs through application of zero-valent iron (ZVI) or magnesium. While laboratory testing on sediments from the Housatonic River has shown promising results (e.g., 84% PCB removal in one day), mass balance analyses have not yet been able to account for all PCBs removed from the sediment (Mikszewski 2004). As this technology is still in the experimental stage, no information is yet available on the performance of a demonstration-scale or full-scale application. Addition of *in situ* activated carbon amendments has shown promise in field tests, while research on delivery methods is ongoing (Luthy et al. 2009, Cho et al. 2007, Werner et al. 2006, Zimmerman et al. 2005). The progress of this technology will be reviewed, and may be considered during the development of Area-specific FS Reports, as appropriate.

In situ biological treatment also was not retained for the preliminary process option screening because it has not yet been successfully implemented at full scale for PCBs. In order for *in situ* biological remediation to succeed, the key contaminants must be bioavailable to microorganisms, and the microorganisms must feed on the target compounds rather than other substrates. To date, these conditions have not been successfully achieved (Renholds 1998; Mikszewski 2004). Further, the effective delivery of reagents to the sediment has not been successfully demonstrated to date.

PCBs are resistant to microbial degradation for the following reasons (Renholds 1998):

- Contaminant toxicity to microorganisms.
- Preferential feeding of microorganisms on other substrates.
- Microorganisms' inability to use a compound as a source of carbon and energy.
- Unfavorable environmental conditions in sediments for propagation of appropriate microorganisms.
- Poor contaminant bioavailability to microorganisms.

Studies carried out with sediments from the upper Housatonic River and Woods Pond in Massachusetts have shown that reductive dehalogenation can occur when the microbial community has been primed with brominated biphenyls (Bedard et al. 1998). Although cultures of the bacteria that carry out this reductive dehalogenation have been successfully identified and developed in laboratory settings, a remedial method based on this technology has not yet been developed (Bedard et al. 2006) or tested in the field.

3.2.7 Summary of Retained Technologies and Process Options

The following technologies (and process options) will be carried forward for further evaluation in the Area-specific FSs as part of alternatives for river sediments:

- No action
- Engineering/institutional controls (physical access restrictions, activity restrictions on fishing and/or hunting, biota consumption advisories, pool elevation control, pool drawdown, and dredging moratorium)
- MNR (MNR and MNR with thin-layer placement)
- *In situ* containment (*in situ* capping and rechannelization)
- Sediment removal (mechanical dredging in the wet, hydraulic dredging, and excavation in the dry)

These technologies/process options will be used, in various combinations, to develop remedial alternatives for sediments. In addition, if other technologies/process options for addressing the sediments are identified during the Area-specific FSs, they may also be incorporated into the remedial alternatives presented and evaluated in the Area-specific FS documents.

3.3 Bank Soils

This section identifies the possible GRAs, associated technologies, and process options available to address unstable or eroding river banks where PCBs are present above relevant risk-based cleanup levels and serve as a source of PCBs to the river system. Stable riverbanks that are not subject to erosion would be addressed where appropriate using the GRAs and associated technologies discussed in Section 3.4 for floodplain soils. The following GRAs relevant to erodible riverbank soils were considered in this technology screening:

- No action
- Engineering/institutional controls
- MNR
- *In situ* containment
- Removal with or without replacement
- Erosion control/bank stabilization

Each of these possible GRAs and associated technologies is described briefly below, followed by a discussion of the preliminary screening of technologies. The results of the preliminary screening of technologies are summarized in Table 1. For those technologies that were retained after the preliminary screening, the associated technology process options were further evaluated and screened. The results of the preliminary process option screening are presented in Table 2.

3.3.1 No Action

The "no action" GRA would not include any active remediation of the riverbanks. This option was retained in the preliminary process option screening because active riverbank remediation to address erosion would not be necessary in areas where bank erosion is not a significant problem and/or where PCBs are not present in the erodible bank materials. Additionally, the “no action” alternative was retained to provide a baseline against which other remedial options for the riverbanks will be assessed.

3.3.2 Engineering/Institutional Controls

Engineering/institutional controls are physical, legal, and/or administrative controls that would be implemented to limit potential exposure to PCBs in bank soil. These controls can be used, alone or in combination, to restrict access to portions of the Site and/or to initiate and maintain appropriate uses that mitigate the potential for future exposure to PCBs during and after remedy implementation. Engineering/institutional controls to address bank soil can include access restrictions (such as fences and signs), land use restrictions, and consumption advisories (e.g., limiting consumption of biota).

Engineering/institutional controls can be used at all stages of the remedial process to mitigate the potential for exposure to contaminated bank soil. They are often used in conjunction with other GRAs (e.g., soil removal, *in situ* containment) both during and following remedy implementation. Engineering/institutional controls have been implemented at the Site to control and reduce the exposure potential to soil contaminants by receptors. Thus, engineering/institutional controls were retained for the preliminary process option screening.

3.3.3 Monitored Natural Recovery

Monitored natural recovery is a GRA that relies on ongoing, naturally occurring processes to contain, destroy, or otherwise reduce the bioavailability or toxicity of chemical constituents in bank soils, with monitoring to assess the rate and degree of recovery or attenuation. In particular, ongoing geomorphic processes in the former impoundments will eventually result in more gradual bank slopes and a more mature state of vegetation such that root mass stabilization and mixing and covering of bank soils with natural materials will reduce PCB exposure and reduce inputs to the river associated with bank erosion. Thus, MNR for bank soil PCBs was retained for the preliminary process option screening. To the extent that these geomorphic processes include the erosion of PCB-containing materials, potential risks associated with exposure to those PCB-containing materials may be reduced at the area in question, and may require evaluation of extent to which potential risks may be transferred to downstream areas.

3.3.4 *In Situ* Containment

This GRA would involve the placement of some type of physical barrier over PCB-containing bank soils to mitigate the potential for exposure to human and ecological receptors. There are various types of barriers that could be used for this purpose including: 1) placement of a simple soil cover over the existing soils, which would provide a clean surface and minimize potential biotic contact with the underlying soil, while not restricting the movement of water from precipitation into and through the soil cover, 2) adding pavement over the underlying soils to provide a barrier to contact, and 3) placement of an engineered barrier, which can be either vegetated or paved and typically involves several layers (including an impermeable layer) to isolate the underlying soil, minimize erosion of that soil, and minimize infiltration of precipitation that could result in potential migration of contaminants. *In situ* containment options are sometimes implemented following partial removal or bank contouring, and are typically implemented in conjunction with activity and use restrictions, which prohibit or restrict interference with the barrier and thus provide further assurance that the potential for exposure is minimized.

In situ containment options have been implemented at numerous PCB-contaminated sites to mitigate the potential for human and ecological exposure. As described in Section 3.2.4, river rechannelization can be a measure of *in situ* containment and has been successfully applied at sediment sites to mitigate the potential for exposure to chemical constituents in sediment and riverbanks by humans and ecological receptors. *In situ* containment options can be used as a stand-alone remedy or combined with other technologies/process options (e.g., institutional controls, removal, and replacement) to create a multi-component approach. For these reasons, *in situ* containment has been retained for the preliminary process option screening.

3.3.5 Removal with or without Replacement

Removal with replacement would involve the physical excavation of PCB-containing soil from erodible riverbank areas, followed by backfilling/regrading of the bank with clean soil. Removal without replacement involves the physical excavation of PCB-containing bank soil without introducing any fill material. These two options may be used in combination depending on site-specific conditions. Depending on the final slope and proximity of the excavated bank to the river’s flow (e.g., on the outside or inside bend of the river, or along a straight reach), final restoration for both options would include some combination of reseeding, plantings, and/or armoring.

Bank soil removal with or without replacement techniques have been demonstrated at full scale at a number of river sites including the Unnamed Tributary (OH), Cedar Creek (WI), Fields

Brook Site (OH), and the Upper ½-Mile and 1½-Mile Reaches of the Housatonic River. Removal of the erodible portions of the bank that contain PCBs would eliminate a potential future source of PCBs to the river. Due to its prior use at this and other sites, and the ability to combine removal with other technologies (e.g., bank stabilization) as part of a remedial alternative, this technology has been retained for the preliminary process option screening.

3.3.6 Erosion Control

Bank stabilization is a common practice used in aquatic environments to prevent or control erosion. The design objective for stabilization would be to isolate PCB-impacted riverbank soil and mitigate the potential for erosion of the bank soils into the river. Many engineering techniques are available to control bank erosion, including so-called “hard” and “soft” techniques. Hard techniques typically involve the construction of structures that reduce flow or wave energy reaching the natural riverbank or that absorb and reflect the wave energy. Commonly employed bank stabilization options include placement of riprap or armor stone, revetment mats, retaining walls, and gabions. Soft techniques involve bank contouring, placement of natural woody debris and materials, and carefully selected plant species to revegetate riverbank soils. These vegetation-based approaches may provide desirable habitat conditions that differ from those presented by hard-armor options. The amount and type of erosion protection that is required or appropriate to stabilize a bank varies with the location within the river system.

Bank stabilization techniques have been demonstrated at full scale at a number of aquatic sites. Through placement of armoring and/or installation of some form of a retaining wall or confining unit, the riverbank soils are physically isolated from the river, reducing the potential for erosion and the mobility of PCBs in the riverbank soil. Because this technology can be combined with other technologies (e.g., bank soil removal) and has been successfully applied at this and other sites with PCB-containing riverbank soil, it has been retained for the preliminary process option screening.

3.3.7 Summary of Retained Technologies and Process Options

The following technologies (and process options) will be carried forward for further evaluation in the Area-specific FSs as potential means of addressing erodible riverbank soils containing PCBs:

- No action

- Engineering/institutional control (access restrictions, land use restrictions, and consumption advisories)

- MNR

- *In situ* containment/capping (soil or pavement cover, multi-layer engineered barrier, and rechannelization)

- Removal with or without replacement (excavation and excavation with backfilling)

- Erosion control/bank stabilization (armor stone barrier, retaining wall, revetment mat cover, gabions, and vegetation cover,)

These technologies/process options will be used, in various combinations, to develop remedial alternatives for bank soils. In addition, if other technologies/process options for addressing erodible riverbanks are identified in the Area-specific FSs, they may also be used in the sediment remedial alternatives presented and evaluated in an Area-specific FS Report.

3.4 Floodplain Soils

The following GRAs were considered and screened to address PCBs present in floodplain soils:

- No action

- Engineering/institutional controls

- MNR

- *In situ* containment

- Restoration-Based Remediation

- Removal with or without replacement

- Erosion control

- *In situ* treatment

Each of these possible GRAs and associated technologies are described briefly below, followed by a discussion of the preliminary screening of technologies. The results of the preliminary screening of technologies are summarized in Table 1. The associated technology process options were further screened for those technologies that were retained after the preliminary screening. The results of the preliminary process option screening are presented in Table 2.

3.4.1 No Action

The “no action” GRA for floodplain soil would not include any active or passive remediation. As noted above, the NCP requires that a “no action” alternative be considered at every site (40 CFR 300.430[e][6]). Thus, this alternative was retained in the preliminary screening of technologies.

The “no action” GRA was also retained in the preliminary process option screening step. This GRA may be appropriate for floodplain areas where potential human exposure is not reasonably anticipated (e.g., due to steep slopes or the wet nature of the areas) and in areas where the damages anticipated due to remediation (e.g., in ecologically sensitive habitat areas) outweigh the potential benefits. There are no technical or administrative conditions that would preclude implementation of “no action” as a remedy component. Further, the “no action” alternative can provide a baseline against which other floodplain alternatives can be assessed in the Area-specific FSs. For these reasons, and in accordance with the NCP, the “no action” alternative has been retained for evaluation in the Area-specific FSs.

3.4.2 Engineering/Institutional Controls

Engineering/institutional controls are physical, legal, and/or administrative controls that are implemented to limit potential exposure to PCBs in floodplain soils by humans and/or ecological receptors. Such controls can be used to restrict access to and use of the site, and can be implemented to maintain appropriate uses that mitigate the potential for future human and, to some extent, ecological exposure to PCB-containing soil. Engineering/institutional controls for floodplain soils may include, but are not limited to, physical access restrictions (such as fences and signs), activity and use restrictions (including deed restrictions), and information devices (such as biota consumption advisories).

Engineering/institutional controls can be used to mitigate the potential for exposure to PCBs in floodplain soils. They are frequently a necessary component of a comprehensive remedial alternative and can be used alone (in certain areas) or in conjunction with other technologies/process options (e.g., removal and replacement, *in situ* containment) when the concentrations of PCBs that remain in place exceed those that are deemed protective for unrestricted uses. Engineering/institutional controls have been successfully used to reduce direct exposure opportunities at sites involving PCB-contaminated floodplain soils. Because of these circumstances, they were retained for the preliminary process option screening.

3.4.3 Monitored Natural Recovery

Floodplains can function as depositional features in river systems. Processes generally described for sediments and bank soils (e.g., deposition of clean material at the surface and mixing/dilution by bioturbation) may also take place on the floodplain where the river and floodplain interact. MNR was retained for the preliminary process option screening.

3.4.4 *In Situ* Containment/Capping

This GRA would involve the placement of some type of physical barrier over the PCB-containing floodplain soils to mitigate the potential for exposure to human and ecological receptors. There are various types of barriers that could be used for this purpose. One of them involves the placement of a simple soil cover over the existing soils, which would provide a clean surface and minimize potential human and biotic contact with the underlying soil, while not restricting the movement of water from precipitation into and through the soil cover. Another option is placement of an engineered barrier, which can be either vegetated or a multi-layer cover (including an impermeable layer) to isolate the underlying soil, minimize erosion of that soil, and minimize infiltration of precipitation that could result in potential migration of contaminants. *In situ* containment options are sometimes implemented following removal, and are typically implemented in conjunction with activity and use restrictions which prohibit or restrict interference with the barrier and thus provide further assurance that the potential for exposure is minimized.

In situ containment options have been implemented at numerous other sites to mitigate the potential for human and ecological exposure to PCBs. *In situ* containment options can be used as a stand-alone remedy or combined with other technologies/process options (e.g., institutional controls and removal and replacement) to create a multi-component approach.

3.4.5 Restoration-Based Remediation

Another possible GRA for floodplain soils is *in situ* restoration-based remediation. This approach, which can include the application of a soil cover and addition of various soil amendments and natural organic materials to bind PCBs, may achieve risk-reduction goals in floodplain soils by reducing the bioavailability of PCBs in conjunction with improving fertility and habitat quality (Chambers 1991). Restoration-based remediation measures may also include phyto-remediation—a range of processes mediated by vegetation planted in the zone targeted for action—an approach that could have the added benefit of promoting habitat development (Sung et al. 2003; Sung et al. 2004; Mackova et al. 2009).

Soil improvements and fertility enhancements may be implemented by placing/tilling clean soils into surface floodplain soils or adding fertilizing agents or other suitable materials. Guidance is available for analyzing soils to determine suitable ranges of soil amendments which will support healthy growth of target vegetation species (USEPA 2007c; Interstate Technology and Regulatory Cooperation Work Group [ITRC] 1999; van Herwijnen 2006). The principal amendments are organic material (e.g., compost or manure), pH control, and inorganic nutrients (Nitrogen, Phosphorus, and Potassium). A number of studies have monitored the effectiveness of soil amendments in sites impacted by heavy metals, petroleum hydrocarbons, and volatile organics. Similar studies of PCBs have been conducted in laboratory or small soil samples. Crowley and Borneman (2006) studied the mechanisms and soil additives which affect plant-produced substances in the rhizospheres that encourage bacterial species responsible for PCB and PAH degradation. Zwiernik et al (1998) used FeSO4 as a soil amendment to stimulate partial anaerobic PCB dechlorination of Aroclor 1242. Gruden et al. (2004) amended Ottawa River sediments containing PCB using Hydrogen Release Compound (HRC, Regenesis, San Clemente, CA) to serve as a hydrogen donor. Their laboratory results demonstrate that increasing amounts of HRC increase anaerobic microbial activity as shown by increased biogas production, and subsequently a reduction in the concentration of lower-chlorinated PCB congeners. In addition to reducing concentrations of PCBs in surface soils available for potential exposure via dilution, such amendments may also reduce the mobility, toxicity, or bioavailability of PCBs in floodplain soils (Dutta et al. 2003; Grundy et al. 1996). Soil or soil amendments may promote the growth of desirable vegetation and habitats. For these reasons, *in situ* restoration-based remediation of floodplain soils has been retained for the preliminary process option screening.

3.4.6 Removal with or without Replacement

This GRA involves the physical removal of PCB-containing soil from the floodplain with or without replacement of material by backfilling, as necessary, with clean soils. These two options may be used in combination depending on site-specific conditions. This process typically employs readily available earthmoving equipment such as backhoes and bulldozers.

Soil removal with or without replacement has been used to mitigate the potential for human and ecological exposure at a number of floodplain properties adjacent to the Kalamazoo River (e.g., the ongoing time-critical removal action at the former Plainwell Impoundment) and at other sites where PCBs were present in the floodplain soils. Accordingly, this technology/ process option has been retained for the preliminary process option screening.

3.4.7 Erosion Control

Erosion control technologies can be used to prevent or control the erosion of floodplain soils. The objective would be to isolate PCB-impacted floodplain soil and mitigate the potential for erosion of the floodplain soils during a potential flood event. Depending on the characteristics of the floodplain areas, engineering techniques available to control floodplain soil erosion may include revetment mats and vegetation covers. This option can also be considered as part of the *in situ* containment technology (Section 3.4.3).

Erosion control techniques have been demonstrated at full scale at a number of sites. Restoration-based soil remediation measures may be applied to control soil erosion. Soil covers may be applied to floodplains to control sources of PCBs (e.g., exposed sediment in former impoundments) by isolating or reducing the mobility and bioavailability of PCBs in the floodplain soils. Soil or soil amendments may be applied or mixed into floodplain soils in conjunction with soil covers to improve the fertility of the soil cover and to promote the growth of desirable vegetation to improve and restore desirable habitats in conjunction with controlling erosion and reducing potential exposure (Smith et al. [2007] studied the effects of amendment and plant types on phyto-remediation of PCB-contaminated sediment). Because this technology can be combined with other technologies (e.g., floodplain soil removal, capping) and has been successfully applied at sites with PCB-containing floodplain soil, it has been retained for the preliminary process option screening.

3.4.8 *In Situ* Treatment

As discussed in Section 3.2.6, *in situ* treatment involves using physical, chemical, or biological processes to destroy or degrade contaminants or to immobilize the contaminants in place.

Immobilization/stabilization technology (physical treatment) utilizing binding agents such as cement or kiln dust may be applied to immobilize PCBs in floodplain soil to reduce the mobility and bioavailability of PCBs in floodplain soils during potential flood events. *In situ* immobilization may not be compatible with floodplain habitat or agricultural use and potential future uses of floodplain areas. In addition, any resulting volume increase could result in flood storage issues and potential freeze/thaw integrity issues.

In situ physical treatment was not retained for the preliminary process option screening for its potential application to floodplain soils at the Site. For the same reasons described in Section

3.2.6 for in-stream sediments, *in situ* treatment using chemical and biological means were not retained for floodplain soils.

3.4.9 Summary of Retained Technologies and Process Options

The following technologies (and process options) will be carried forward for further evaluation in the Area-specific FSs as part of remedial alternatives for the floodplain soils:

- No action
- Engineering/institutional controls (access restriction, land use, and consumption advisories)
- MNR
- *In situ* containment (soil or pavement cover and engineered barrier)
- *R*estoration-based remediation (soil cover, amendments, or plantings to promote phyto-remediation)
- Removal with or without replacement (excavation and excavation with backfilling)
- Erosion control (revetment mats, vegetation covers, and restoration-based soil remediation)

In addition, if other technologies/process options for addressing floodplain soils are identified during the development of Area-specific FSs, they may also be considered and incorporated into the remedial alternatives presented in the Area-specific FS documents.

3.5 Management of Dredged or Excavated Material

Should the Site remedy involve the removal of PCB-containing materials (e.g., dredging or excavation), the removed material (i.e., sediment or soil) may require processing and handling for proper treatment and disposal. This section describes the possible GRAs, associated technologies, and process options considered to address PCBs in removed sediment, riverbank soil, and floodplain soil.

To manage the removed material, the following GRAs were considered in this preliminary screening:

- Solids dewatering
- Stormwater management
- Process water management
- *Ex situ* treatment (physical, biological, chemical, and thermal treatments)
- Transportation (truck, barge, rail, and pipeline)
- Disposal

Each of these possible GRAs and associated technologies is briefly described below, followed by a discussion of the preliminary screening of technologies. The results of the preliminary screening of technologies are summarized in Table 1. The associated technology process options were further screened for those technologies that were retained after the preliminary screening of technologies. The results of the preliminary process option screening are presented in Table 2.

In most instances, the technologies/process options within these possible GRAs could not be used alone, but would need to be combined with other technologies/process options. For example, for removed sediments, the dewatering and *ex situ* treatment or disposal technologies would need to be combined with one or more of the options for disposal or reuse of the dewatered or treated material.

3.5.1 Solids Dewatering

Solids dewatering would likely be needed to remove excess water from removed sediments and saturated soils to facilitate their handling and treatment or disposal. Dewatering is typically performed using some combination of mechanical and/or gravity-assisted techniques, which are briefly described below:

- **Mechanical dewatering** is accomplished when slurry from the removed material is pumped or fed through a filtration device or subjected to centrifugal forces. Examples of mechanical dewatering equipment include the belt filter press, plate and frame filter press, solid-bowl (centrifuge) equipment, and the evaporator. These dewatering process options are usually required for sediments that are hydraulically dredged and sometimes used for mechanically dredged sediments.

- **Gravity dewatering** typically involves allowing the removed sediment and soil to settle and consolidate on a lined, bermed pad or in a tank, basin, or other device. Geotubes, in which slurry (hydraulically dredged material) is pumped into fabric tubes and consolidated as liquids are forced out of the tubes, may also be used. Depending on sediment type and the area/container being used in the gravity dewatering process, flocculating agents can be added to enhance the dewatering process.

Mechanical and gravity dewatering techniques have been successfully applied at a number of sediment sites where PCB-containing sediments were removed for processing and disposal including the Housatonic River (MA), the Fox River (WI), the St. Lawrence River (NY), Manistique Harbor (MI), and New Bedford Harbor (MA). Depending on the material characteristics and the removal methods used, some form of solids dewatering is currently anticipated for those remedial alternatives that include sediment removal as a remedy component. Given their use at other sites and their potential applicability for processing wet sediments and soils removed from the Kalamazoo River, mechanical (belt filter press; plate and frame filter press) and gravity (stockpile, thickener, settling basin, GeoTubes) dewatering process options have been retained for further consideration. As indicated in Table 2, the solid bowl and evaporator mechanical dewatering process options were not retained after the preliminary screening step.

3.5.2 Stormwater Management

Stormwater would likely need to be managed in the vicinity of PCB-containing soil/sediment that has been removed for processing and disposal. Stormwater management is typically performed using a combination of diversion techniques and collection with treatment, as briefly described below:

- **Collection with treatment** involves capturing stormwater that has potentially contacted PCB-containing soil/sediment using a combination of piping, catch basins, and water treatment. These process options are usually required during construction activities to prevent the mobilization of PCB-containing soil/sediment.

- **Diversion** techniques involve directing stormwater away from PCB-containing soil/sediment that has been removed for processing and disposal to prevent the stormwater from becoming impacted with PCBs. Examples of diversion techniques include hay bales, silt fencing, etc.

Stormwater management, including collection with treatment and diversion techniques, has been successfully applied at a number of sediment sites where PCB-containing sediments were removed for processing and disposal. Given their use at other sites and their potential applicability to mitigate the mobility of PCBs from the sediments/soils removed from the Site, collection with treatment and diversion techniques were retained for the preliminary process option screening.

3.5.3 Process Water Management

The processing of removed sediments (whether by mechanical or hydraulic dredging) will produce a quantity of water from dewatering operations. This water may require additional treatment to achieve a composition compatible with discharge to the Kalamazoo River or to a local sewer.

Water treatment processes may be required for the control of particulate or soluble constituents, or both. Particulate constituents are typically removed by gravity settling and multimedia (sand and anthracite) filtration. Chemical treatments (coagulants and/or flocculants) may be added before settling and filtration to enhance the removal of solids. These chemical treatments may also remove some soluble constituents by adsorption or precipitation. When sediments contain PCBs, the water treatment processes usually require the use of activated carbon adsorption to achieve regulated levels of PCB in the discharged effluent.

3.5.4 *Ex situ* Treatment

3.5.4.1 *Ex situ* Physical Treatment

Ex situ physical treatment involves physically stabilizing the removed materials by mixing immobilization agents and/or segregating PCB-containing solids via particle separation. An example of *ex situ* physical treatment includes physical mixing of cement-based or pozzolanic reagents with sediment and soil to form a stabilized mass that binds PCBs and sediment and soil particles. Another example is the separation of fine particles (i.e., silt- and clay-size particles) from the coarse fraction (i.e., sand- and gravel-sized particles) through soil washing technology; this may be worth considering to reduce disposal costs if the PCBs in the removed material are preferentially bound to a particular material size fraction.

Ex situ physical treatment has been successfully applied at a number of sediment sites where PCB-containing sediments were removed for processing and disposal, including the Unnamed Tributary (OH), where a cement-based product was added to the sediments prior to disposal (BBL 2000), and Manistique Harbor (MI), where particle separation was used to separate dredged sediments from wood chips that contained high concentrations of PCBs (Committee on Contaminated Marine Sediments 1997). Given its use at other sites and its potential applicability for stabilizing or treating wet sediments and/or soils removed from the Site, *ex situ* physical treatment was retained for the preliminary process option screening.

3.5.4.2 *Ex situ* Biological Treatment

Ex situ biological treatment involves landfarming or amending the removed sediment and soil to enhance the biodegradation of PCBs using microorganisms and nutrients in an aerobic or anaerobic environment. Available *ex situ* biological treatment technologies include the addition of oxygen and minerals, possibly combined with cultured microorganisms, to increase the level of microbially mediated degradation reactions occurring in sediment and soil.

Ex situ biological treatment approaches to reduce the concentration/toxicity of PCBs in sediments and soil have been field tested quite extensively (Pointing 2001; Ruiz-Aguilar et al. 2002; Kamei et al. 2006). Although certain microbes have been identified which are capable of PCB biodegradation and dechlorination, no processes have successfully demonstrated significant reductions in total PCB concentrations, nor have any full-scale applications of *ex situ* biological treatment to remediate PCBs in sediment or soil been noted. In general, *ex situ* biodegradation is a slow and labor-intensive process, and full-scale implementation would require the use of large areas of land for setup and operation. For these reasons, *ex situ* biological treatment was not retained for the preliminary process option screening.

3.5.4.3 *Ex situ* Chemical Treatment

Ex situ chemical treatment involves mixing chemical surfactants, solvents, or other liquids with excavated PCB-containing sediment and soil to remove or destroy PCBs. Removed PCBs and the surfactant, solvent, or other liquid would require further treatment or disposal. Chemical treatment processes may include common or proprietary solvents and other liquids.

Ex situ chemical treatment was applied at the Sparrevohn Long Range Radar Station Site (AK), where solvent extraction was used to reduce average PCB concentrations from 80 milligrams per kilogram (mg/kg) in the untreated soils to 3.27 mg/kg in the treated soil (USEPA 1998b). A total of 288 cubic yards (cy) of stockpiled soil were treated in 85 cy batches using solvent extraction in lined treatment cells. The solvent was reclaimed and burned onsite (USEPA 1998b). The final disposition of the treated soil could not be verified based on a review of available information. Full-scale demonstration of chemical extraction using BioGenesis^{SM} is currently underway using sediment from NY/NJ Harbor and the Lower Passaic River (USEPA 1999b, 2006a). However, this project involves sediments with relatively low PCB concentrations, and thus may not evaluate the ability of BioGenesis^{SM} to extract PCBs from sediments with higher concentrations. Full-scale demonstration of chemical extraction using

B.E.S.T.® Solvent Technology for sludge impacted with PCBs was also conducted at the General Refining, Inc. (GA) Superfund Site (USEPA 1993). The PCB concentrations in the sludge were reportedly reduced by approximately 99%; however, the preliminary concentrations in the untreated sludge ranged up to only approximately 14 mg/kg. The USEPA Assessment and Remediation of Contaminated Sediments (ARCS) Program reported approximately >95% to 99% reduction of PCBs in sediments from the Buffalo River, Saginaw River, and Grand Calumet River in a bench-scale study using the Resources Conservation Company (RCC)'s B.E.S.T.® process (USEPA 1994).

The Springfield Township (MI) Superfund Site reportedly remediated more than 12,000 tons of PCB-impacted soil with concentrations greater than 50 mg/kg by implementing a chemical extraction treatment provided by ART International, Inc. (USEPA 2004b). The final cleanup goal for the site was 1 mg/kg PCBs in soil; however, treated soils containing residual levels up to 5 mg/kg of PCBs were backfilled into the excavation areas, covered with a 1-foot-thick layer of clean soil, and revegetated (USEPA 2004b).

Given its use at other sites and its potential applicability for treating sediments and soils removed from the Site, the *ex situ* chemical extraction process option was retained for further consideration. As indicated in Table 2, *ex situ* chemical destruction was not retained after the preliminary screening step.

3.5.4.4 *Ex situ* Thermal Treatment

Ex situ thermal treatment involves heating the PCB-containing sediment and soil to temperatures high enough to remove or destroy PCBs. This includes relatively low-temperature extraction that involves carrier gases to remove volatilized PCBs (which are then treated or destroyed), as well as high-temperature destruction, where excessive heat destroys the PCBs in the removed material.

***Ex situ* thermal treatment** (desorption) was applied at the Outboard Marine Corporation Superfund Site (IL), where a rotary kiln was used to reportedly achieve 99.98% PCB removal efficiency on 12,755 tons of soil/sediment with preliminary PCB concentrations ranging from 2,400 to 23,000 mg/kg (USEPA 1995). Cleanup goals at that site were reached with concentrations in treated soils and sediments ranging from 0.4 to 8.9 mg/kg. Most concentrations after treatment were below 2 mg/kg (USEPA 1995). The treated soil and sediment were placed in containment cells onsite. In addition to treated solids, the end products of the thermal treatment included vapor and flue gas. The vapor was recovered from two locations in the treatment system, resulting in condensed water and approximately 50,000 gallons of oil containing PCBs. The condensed water was treated in an onsite wastewater treatment system and discharged to a sanitary sewer. The oil was collected and disposed of offsite. The flue gas was treated and released to the atmosphere. The fines recovered during the flue gas treatment were mixed with treated solids (USEPA 1995).

***Ex situ* thermal treatment** (low-temperature thermal desorption) was applied at the Re-Solve, Inc. Superfund Site (MA), where a rotary kiln was used to reportedly achieve the cleanup goal of 25 mg/kg for PCBs on approximately 37,500 cubic yards of soil and sediment (USEPA 2003). The 1987 Record of Decision for the Re-Solve Site indicated that PCB levels of the untreated soil/sediment ranged upwards of 500 mg/kg (USEPA 1987). After treatment, the soil and sediment were backfilled in a designated onsite waste disposal area and capped with 18 inches of gravel. The preliminary remedy selected included plans for dechlorination following thermal treatment; however, after completing the pilot tests, the dechlorination system was eliminated from the full-scale design due to the larger than anticipated volume of dechlorination residuals predicted by the pilot study. Instead, the PCB-contaminated oil generated by the thermal treatment system was disposed of at an offsite Toxic Substances Control Act (TSCA)-permitted incinerator (Halliburton NUS Environmental Corporation and Badger Engineers, Inc. 1993).

Thermal destruction, another *ex situ* thermal treatment process, has been demonstrated on full-scale applications at sites with PCB-containing media (USEPA 1998a). Full-scale applications at Superfund sites generally exceeded 99.99% destruction for PCBs and produced off-gases and combustion residuals (ash) which required treatment (USEPA 2004c). Combustion residuals generated from onsite incineration would likely not be suitable as fill without the addition of amendments (i.e., organics) and, as such, would likely be disposed of in a landfill after pretreatment. Flue gases from incineration units need to be cooled quickly to minimize the possibility of organics like dioxins forming in the stack emissions. The high moisture content and low thermal content of sediments would require additional fuel for drying and to sustain the incineration process.

Given its use at other sites and its potential applicability for stabilizing/treating sediments and/or soils removed from the Site, the *ex situ* thermal desorption process option was retained for further consideration. As indicated in Table 2, *ex situ* thermal destruction was not retained after the preliminary screening step.

3.5.5 Transportation

Transportation would be required to move dredged or excavated sediments from the Areas of the Site to a nearby processing facility. The facility may be adjacent to the river or some distance away. This pre-processing transport will likely take the form of barging (for mechanically excavated sediments) or pipeline transport (for hydraulically excavated sediments). Processing may involve water removal and addition of solidification or stabilization amendments to the removed sediments. The post-processed sediments could then be transported to a final disposal location as discussed below. The most likely forms of transportation for processed sediments and soils include trucks, rail cars, barges, or a pipeline (for hydraulically dredged sediment). The selected forms and routes of transportation will depend on the disposal site location, existing transport routes, and economic factors.

3.5.6 Disposal

3.5.6.1 Confined Disposal Facility

Local disposal may be a viable option for managing removed material. Such disposal could take the form of a confined disposal facility (CDF) or confined aquatic disposal (CAD) facility constructed within the water in the Kalamazoo River area or in a nearby, newly constructed upland disposal facility. These are described below:

- **Disposal in an in-water CDF or CAD facility** would involve the placement of sediment and/or soil in a disposal facility constructed within a water body at the Site.

- **On-land CDF** would involve the post-dewatering placement of PCB-containing sediment and soil in an upland disposal facility constructed in close proximity to the Site.

The in-water and on-land disposal options being considered for removed materials (CDF, CAD and upland disposal) have been implemented at a number of sediment sites where PCB-containing sediments were removed for disposal. For example, the removal actions for sites such as the Housatonic River (MA), the Ashtabula River and Harbor Site (OH), and the Waukegan Harbor Site (IL) have used upland local disposal. Additionally, in-water CDFs have been used to dispose of sediments containing PCBs at sites including New Bedford (MA). Implementation would require approval to obtain and use property to construct the CDF, CAD or on-land disposal facility. Since the 1960s, the U.S. Army Corps of Engineers has constructed 43 confined disposal facilities around the Great Lakes. Of these, 16 were constructed on land and 27 were built as in-water facilities (sometimes at shore-adjacent locations).

These disposal facilities can be designed to receive removed sediment and soil from one or more Areas of the Site. Given their use at other sites and their potential applicability for disposition of sediments and soils removed from the Site, the CDF, CAD and on-land disposal facility options have been retained for the preliminary process option screening.

3.5.6.2 Offsite Disposal

In addition to local disposal options, existing, permitted offsite facilities could be used for disposing of sediment and soil removed from the river, riverbanks, and floodplain (following dewatering where necessary). Under this option, PCB-containing sediment and soil would be transported to an offsite permitted facility for disposal.

Disposing of the removed material at an existing offsite disposal facility is a viable option for the sediment and soil removed from the river, riverbanks, and floodplain. Offsite disposal is one of the most commonly used methods for final disposition of removed sediment and soil from remediation projects throughout the United States. It has been employed at a multitude of sites after sediment and soil removal operations. Thus, offsite disposal has been retained for the preliminary process option screening.

3.5.6.3 Beneficial Reuse

The beneficial reuse option would involve treating the removed material and then using it in beneficial ways, such as cover material for solid waste landfills, or converting it into useable products such as cement, light-weight aggregate, or glass tile.

For the beneficial reuse option to be effective, the removed material would require additional treatment to meet beneficial reuse standards. The type and level of treatment necessary would depend on the future beneficial use of the material, physical characteristics of the sediment or soil, and PCB concentrations. For uses such as cover material for solid waste landfills or conversion into usable products, the removed materials would require treatment to meet applicable reuse standards. Following treatment, a sampling, analysis, and verification process would be required to demonstrate that applicable remedial standards have been achieved. Soil would then be transported from the treatment location to the location where the beneficial use would take place.

It is unlikely that a significant portion of the treated site materials would have PCB content low enough to be candidates for beneficial reuse. In addition, if the material requires treatment for other constituents, the treatment process may become increasingly complicated. Furthermore, the cost associated with implementation of this option would be high relative to the cost of disposal within a local or offsite disposal facility.

To date, few dredged sediment sites have employed beneficial reuse, mainly due to the lack of available cost-effective reuse options (USEPA 2005). A full-scale demonstration project is currently underway for sediments dredged from the NY/NJ Harbor Federal Navigation Channel to assess the usability of treated sediments as a manufactured soil, architectural tile, and a cement additive (USEPA 2006a). While the thermal treatment and chemical treatment technologies being tested are apparently capable of treating PCBs, the typical range of PCB concentrations reported in the NY/NJ Harbor sediments is 0.05 to 3.32 mg/kg (MWH 2005), which is significantly lower than the range of concentrations in Kalamazoo River sediments and soils. No sites have been identified where a beneficial reuse technology was successfully applied at full scale to treat sediments or soils with PCBs with concentrations comparable to those in the sediments and soils of the Kalamazoo River.

Beneficial reuse has not been retained for the preliminary process option screening due to the lack of any successful full-scale projects with sediments or soils containing PCB concentrations similar to those of the Kalamazoo River and because of the likely high cost associated with the requirement that the material meet restrictive beneficial reuse standards.

3.5.7 Summary of Retained Technologies and Process Options

The following technologies (and process options) will be carried forward as options for handling sediment and soil removed from the Kalamazoo River, riverbank, and floodplain areas:

- Dewatering (mechanical and gravity processes)
- Stormwater management (collection and treatment and diversion)
- Water treatment (onsite treatment and offsite treatment)
- *Ex situ* Treatment (stabilization/solidification, particle separation, chemical extraction, and thermal desorption)
- Transportation (truck, barge, rail, and pipeline)
- Disposal (in-water and on-land CDFs and offsite disposal facility).

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Tables

Table 1 – Preliminary Screening of Technologies

Possible General Response Action	Remedial Technology	Description	Preliminary Screening of Remedial Technologies			
			Technology by Medium			Auxiliary Technology
			In-Stream Sediment	Bank Soil	Floodplain Soil	Ex Situ Management of Dredged or Excavated Material
No Action	No Action	No active or passive remediation or associated long-term monitoring or controls.	Retained	Retained	Retained	NA
Engineering/ Institutional Controls	Engineering/ Institutional Controls	Implementing physical, legal, and/or administrative controls to limit potential exposure to PCBs in sediment or soil.	Retained	Retained	Retained	NA
Monitored Natural Recovery (MNR)	MNR	Monitoring to confirm the natural physical, chemical, and/or biological processes that contain, destroy, or reduce the bioavailability or toxicity of PCBs in sediment, or soil.	Retained	Retained	Retained	NA
	Enhanced MNR	Accelerating the natural recovery process by engineering means.	Retained	NA	NA	NA

Table 1 – Preliminary Screening of Technologies

Possible General Response Action	Remedial Technology	Description	Preliminary Screening of Remedial Technologies			
			Technology by Medium			Auxiliary Technology
			In-Stream Sediment	Bank Soil	Floodplain Soil	*Ex Situ* Management of Dredged or Excavated Material
In Situ Containment	Capping	Sediment—Placing a clean layer of isolating material (e.g., clean sand, gravel, cobbles, sorbents, geofabrics) to contain and stabilize the PCB-containing sediment *in situ* and sequester those sediments from the biologically active zone within the sediment bed and from the water column. Sediment capping may be implemented in combination with sediment removal (i.e., removal with replacement.) Soil—Placing material (e.g., clean soil or sand, geofabrics) over PCB-containing bank soil or floodplain soil to mitigate potential exposures by human and ecological receptors.	Retained	Retained	Retained	NA
	Rechannelization	Permanently redirecting the river into a newly constructed or modified channel and covering/isolating the PCB-containing sediment/soil in the original channel in-place.	Retained	Retained	NA	NA

Table 1 – Preliminary Screening of Technologies

Possible General Response Action	Remedial Technology	Description	Preliminary Screening of Remedial Technologies			
			Technology by Medium			Auxiliary Technology
			In-Stream Sediment	Bank Soil	Floodplain Soil	*Ex Situ* Management of Dredged or Excavated Material
Restoration-Based Remediation	Restoration-Based Remediation	Restoration-based remediation using soil cover or amendments to reduce PCB exposure and bioavailability, and promote fertility of the floodplain soils and development of desirable habitats.	NA	NA	Retained	NA
Removal (Sediment) Removal with or without Replacement (Soil)	Dredging Excavation with or without Backfilling	Sediment—Physically removing PCB-containing sediment using mechanical or hydraulic dredging techniques. Sediment may be excavated in the dry utilizing conventional excavation equipment such as backhoes and bulldozers. Soil—Physically removing PCB-containing bank soil or floodplain soil using conventional excavation equipment such as backhoes and bulldozers. Similar equipment is typically used to place backfill material (e.g., clean sand or soil).	Retained	Retained	Retained	NA
Erosion Control	Bank Stabilization	Armoring or isolating the riverbank to prevent soil erosion and reduce the potential mobility of PCBs in the bank soil.	NA	Retained	Retained	NA

Table 1 – Preliminary Screening of Technologies

Possible General Response Action	Remedial Technology	Description	Preliminary Screening of Remedial Technologies			
			Technology by Medium			Auxiliary Technology
			In-Stream Sediment	Bank Soil	Floodplain Soil	*Ex Situ* Management of Dredged or Excavated Material
In Situ Treatment	Physical Treatment	Sediment—Injecting and/or mixing an immobilization agent into the sediment to reduce the mobility and bioavailability of PCBs in the sediment. Soil—Mixing an immobilization agent into the floodplain soil or non-eroding bank soil to reduce the mobility potential of PCBs in the floodplain soil.	Not Retained	Not Retained	Not Retained	NA
	Chemical Treatment	Introducing chemical surfactants/solvents or oxidants into the PCB-containing medium to remove or destroy PCBs either by injection, mixing with a chemical, or placement of a reactive barrier.	Not Retained	Not Retained	Not Retained	NA
	Biological Treatment	Introducing microorganisms and/or nutrients into the PCB-containing medium to increase ongoing biodegradation rates of PCBs in sediments/soils.	Not Retained	Not Retained	Not Retained	NA

Table 1 – Preliminary Screening of Technologies

Possible General Response Action	Remedial Technology	Description	Preliminary Screening of Remedial Technologies			
			Technology by Medium			Auxiliary Technology
			In-Stream Sediment	Bank Soil	Floodplain Soil	*Ex Situ* Management of Dredged or Excavated Material
Solids Dewatering	Mechanical	Pumping or feeding a slurry of dredged material through a filtration device or subjecting the slurry to centrifugal forces to separate solids from water. Examples of equipment include belt filter press, plate and frame filter press, and solid-bowl (centrifuge) equipment.	NA	NA	NA	Retained
	Gravity	Allowing removed sediment and soil to settle and consolidate on a lined, bermed pad and/or in a tank, basin, or other device.	NA	NA	NA	Retained
Stormwater Management	Collection and Treatment	Collecting stormwater that has potentially been in contact with removed PCB-containing soil/sediment and then treating the collected water for discharge.	NA	NA	NA	Retained
	Diversion	Diverting stormwater away from contact with PCB-containing soil/sediment.	NA	NA	NA	Retained
Process Water Management	Water Treatment	Treating water (either onsite or offsite) collected from sediment dewatering processes or stormwater management activities to remove PCBs prior to the discharge of processed water to a stream or municipal sewer system.	NA	NA	NA	Retained

Table 1 – Preliminary Screening of Technologies

Possible General Response Action	Remedial Technology	Description	Preliminary Screening of Remedial Technologies			
			Technology by Medium			Auxiliary Technology
			In-Stream Sediment	Bank Soil	Floodplain Soil	*Ex Situ* Management of Dredged or Excavated Material
Ex Situ Treatment	Physical Treatment	Physically stabilizing the removed sediment/soil by mixing in immobilization agents, and/or separating PCB-containing solids via particle separation.	NA	NA	NA	Retained
	Biological Treatment	Landfarming or amending sediment/soil to enhance the biodegradation of PCBs using microorganisms and nutrients in an aerobic or anaerobic environment.	NA	NA	NA	Not Retained
	Chemical Treatment	Mixing chemical surfactants/solvents with excavated PCB-containing sediment/soil to remove or destroy PCBs. Removed PCBs would require treatment/disposal.	NA	NA	NA	Retained
	Thermal Treatment	Heating PCB-containing sediment/soil to remove and/or destroy PCBs.	NA	NA	NA	Retained
Transportation	Transportation	Transporting removed sediment/soil from excavation/dredge location to treatment/disposal location. Transportation may be performed using truck, rail, barge, or pipeline.	NA	NA	NA	Retained

Table 1 – Preliminary Screening of Technologies

Possible General Response Action	Remedial Technology	Description	Preliminary Screening of Remedial Technologies			
			Technology by Medium			Auxiliary Technology
			In-Stream Sediment	Bank Soil	Floodplain Soil	*Ex Situ* Management of Dredged or Excavated Material
Disposal	In-water Confined Disposal Facility (CDF) or Confined Aquatic Disposal (CAD)	Placing PCB-containing sediment/soil in a disposal facility constructed within a water body.	NA	NA	NA	Retained
	On-land CDF	Placing PCB-containing sediment/soil in an upland disposal facility located or constructed in close proximity to the Site.	NA	NA	NA	Retained
	Off-Site Disposal	Transporting and disposing of PCB-containing sediment/soil at an off-site permitted facility.	NA	NA	NA	Retained
	Beneficial Reuse	Using treated material in beneficial ways, e.g., as cover material for solid waste landfills, or being converted into useable products such as cement, lightweight aggregate, or glass tile.	NA	NA	NA	Not Retained

Notes:
1. NA – Not Applicable

Table 2 – Preliminary Screening of Process Options

Possible General Response Action/ Technology	Process Option	Description	Effectiveness	Implementability	Preliminary Screening
1. In-Stream Sediment					
A. No Action					
No Action	No Action	No remedial measures or monitoring conducted. Would take account of changing conditions through the ongoing natural attenuation of PCBs in sediments.	Appropriate for areas that already meet cleanup goals. No monitoring performed to track effectiveness.	Readily implementable.	Retained per National Oil and Hazardous Substances Pollution Contingency Plan (NCP) and for comparison to other options.
B. Engineering/Institutional Controls					
Engineering/ Institutional Controls	Physical Access Restrictions	Physical constraints, such as fencing and signs, placed around the Site to limit access.	Would reduce potential human exposure to PCBs in sediments. Could be used during implementation of remedial actions and, in some instances, on a longer-term basis. Would require routine monitoring and maintenance.	Technically and administratively implementable. Would require property owner(s) agreement.	Retained.
Engineering/ Institutional Controls	Activity Restrictions on Fishing and/or Hunting	Restrictions, such as catch-and-release fishing restrictions and/or restrictions on certain types of waterfowl hunting, put in place along the Site to prohibit or limit such activities.	Would reduce potential for human exposure to PCBs through ingestion of fish or waterfowl containing PCBs.	Implementable through fishing and hunting regulations and/or license programs. Would require coordination with the appropriate agencies.	Retained.

Table 2 – Preliminary Screening of Process Options (continued)

Possible General Response Action/ Technology	Process Option	Description	Effectiveness	Implementability	Preliminary Screening
B. Engineering/Institutional Controls (Continued)					
Engineering/ Institutional Controls	Consumption Advisories	Advisories established/maintained to limit consumption of certain biota or agricultural products.	Would reduce potential for human exposure by placing restrictions on the consumption of certain biota and agricultural products.	Readily implementable. Currently in place at the Site.	Retained.
Engineering/ Institutional Controls	Pool Elevation Control	Pool elevation controls implemented by the dam owners would minimize the potential for scour, resuspension, and transport of buried PCB-containing sediments.	Would reduce potential exposure of ecological receptors by minimizing the transport of PCB-containing sediment due to scouring and resuspension and the consequent uptake of PCBs by fish and biota. Would assume that the dams and impoundments are operated and maintained by their owners in compliance with applicable laws and regulations prohibiting the exacerbation of existing environmental contamination.	Readily implementable. Dams are currently in place and would require periodic inspection and maintenance.	Retained.
Engineering/ Institutional Controls	Dredging Moratorium	Restricts dredging operations.	Would provide limited protection since it avoids disturbance of existing contaminants and allows natural covering or recovery processes to proceed.	Potentially applicable.	Retained.

Table 2 – Preliminary Screening of Process Options (continued)

Possible General Response Action/ Technology	Process Option	Description	Effectiveness	Implementability	Preliminary Screening
C. Monitored Natural Recovery					
MNR	MNR	Monitoring of natural physical, chemical, and/or biological processes that are continuing to break down or sequester PCBs in sediments.	Would utilize natural processes to reduce potential exposure to human and ecological receptors to PCBs in sediment over time (e.g., dispersion, silting-over with cleaner sediments). Monitoring would be performed to track effectiveness and rate of recovery.	Readily implementable and minimally intrusive. Activities would be limited to river sampling from a boat and/or shoreline. Access, materials, personnel, and equipment are readily available.	Retained.
Enhanced MNR	Enhanced Sedimentation	Constructing dams or other engineered structures to alter the rate of sedimentation in portions of the Site and to increase the rate of natural recovery.	Would reduce potential for human or ecological exposure to PCBs in sediment over time. Effectiveness depends on hydraulic conditions created, loading rates, and quality of sediment deposited. Effective in low-energy aquatic environments (e.g., impoundments). Would require long-term monitoring.	Technically implementable, but could alter local habitat and river use. Implementability considerations for specific Areas would include impacts on surface water elevations, impacts on channel depth, and stability of added sediment layers.	Retained.
Enhanced MNR	Thin-Layer Placement	Placing a thin-layer (a few inches) of clean material over the sediment to provide reduction of sediment PCB concentrations in the biologically active zone and to accelerate natural recovery.	Would reduce potential for human and/or ecological exposure to PCBs in sediment. Effective in low-energy aquatic environments. Can provide a base for sustained long-term reduction in surficial PCB concentrations. Would require long-term monitoring.	Readily implementable. Equipment, materials, and personnel are readily available. Implementability considerations are similar to those for Enhanced Sedimentation.	Retained.

Table 2 – Preliminary Screening of Process Options (continued)

Possible General Response Action/ Technology	Process Option	Description	Effectiveness	Implementability	Preliminary Screening
D. *In Situ* Containment					
Capping	*In Situ* Capping (ISC)	Placing a clean subaqueous cover material over PCB-containing sediments at a thickness suitable to create a clean bioavailable zone. Where necessary, may include a sorptive media (e.g., organic carbon, organoclay) and/or physical barrier (e.g., an impermeable geofabric, clay, AquaBlok™) sufficient to reduce the flux of PCB to the water column. Can be used by itself or after initial removal of sediments.	Would reduce the long-term potential exposure to human and ecological receptors by providing a clean cover over the PCB-containing sediments. Post-construction maintenance and monitoring would be required.	Implementable. Capping by itself is most readily implementable in deeper, lower-energy reaches of the river. Implementation in shallower, higher-energy environments may require some sediment removal prior to capping to address flood storage concerns and to support future river uses. Equipment, materials, and qualified personnel are available. Would require access agreements from the property owners adjacent to the areas of the river to be capped.	Retained.
Rechannelization	Rechannelization	Permanently redirecting a section of the Kalamazoo River into a newly constructed or modified channel, while isolating PCB-containing sediment in the original channel in place (i.e., by covering with clean soil), and restoring the channel to surrounding grade.	Would reduce potential exposure to human and ecological receptors to PCBs by eliminating contact between PCB-containing materials and the river water and human and ecological receptors. Would require long-term monitoring and maintenance and potentially deed restrictions related to materials remaining under the cover in the original channel.	Technically implementable in river reaches where property is available and river configuration is conducive to rechannelization (e.g., oxbows). Equipment, materials, and personnel are readily available. Negotiations with potentially affected landowner(s) would be necessary to acquire sufficient tracts of land for rechannelization and to obtain agreements for access.	Retained.

Table 2 – Preliminary Screening of Process Options (continued)

Possible General Response Action/ Technology	Process Option	Description	Effectiveness	Implementability	Preliminary Screening
E. Sediment Removal					
Dredging	Mechanical Dredging in the Wet	Removing PCB-containing sediment using conventional dredging equipment (e.g., long-reach excavator or clamshell bucket) through the water column.	Would reduce potential long-term exposure to human and ecological receptors through removal of PCB-containing sediments, but may potentially increase short-term exposure due to technological limitations of dredging (i.e., resuspension and release of PCBs, lack of ability to remove all sediment). Difficulties have been noted in achieving low residual PCB concentrations in surface sediments, especially when debris is present and as result of resuspension/ redeposition of finer-grained sediments. Due to dredging technology limitations, management of post-dredging residuals may be necessary (e.g. through placement of post-dredging cover materials, natural attenuation, or other means) to achieve PCB cleanup goals. May increase short-term exposure due to the potential for resuspension and release of PCBs during remedial activities.	Implementable if adequate access (e.g., shoreline access or navigable water depth) is available for equipment operation. Equipment, materials, and personnel are readily available. May not be applicable to all areas of the Site. Would require necessary access permissions and would need to meet substantive requirements of applicable regulations. Damage or loss of sensitive habitats is likely where dredging would impact shoreline areas or significantly impact post-removal water levels. Water body and local vicinity use disruptions due to vehicular traffic and equipment activity are implementability considerations.	Retained.

Table 2 – Preliminary Screening of Process Options (continued)

Possible General Response Action/ Technology	Process Option	Description	Effectiveness	Implementability	Preliminary Screening
E. Sediment Removal (Continued)					
Dredging	Hydraulic Dredging	Removing and transporting sediment in a liquid slurry form using a hydraulic pump or compressed air (e.g., horizontal auger, cutterhead dredge, PNEUMA pump).	Would reduce potential long-term exposure to human and ecological receptors through removal of PCB-containing sediments. May increase short-term exposure due to resuspension/release of PCBs during dredging. Difficulties have been noted in achieving low residual PCB concentrations in surface sediments, especially when debris is present and as result of resuspension/ redeposition of finer-grained sediments. Effectiveness could be limited by presence of debris, and thus mechanical dredging may be required as an initial step. Due to dredging technology limitations, management of post-dredging residuals may be necessary (e.g. through placement of post-dredging cover materials, natural attenuation, or other means) to achieve PCB cleanup goals.	Technically implementable in areas where access to the sediments is feasible, water depths and velocities are adequate to support dredge movement and use, and a sufficiently large area is available to support sediment storage/dewatering operations. Important that removal areas are capable of being adequately contained using resuspension controls due to turbidity generation. Equipment, materials, and personnel are readily available. Conditions such as shallow waters and presence of boulders/debris make this option less feasible than mechanical dredging in some areas. Would require necessary access permissions and would need to meet substantive requirements of applicable regulations. Damage or loss of sensitive habitats may occur where dredging would impact shoreline areas or significantly impact post-removal water levels. Water body and local vicinity use disruptions due to vehicular traffic and equipment activity are implementability considerations.	Retained.

Table 2 – Preliminary Screening of Process Options (continued)

Possible General Response Action/ Technology	Process Option	Description	Effectiveness	Implementability	Preliminary Screening
E. Sediment Removal (Continued)					
Excavation	Excavation in the Dry	Removing PCB-containing sediment using conventional earthmoving equipment (e.g., excavator) after dewatering the removal area (e.g., via pump bypass, rechannelization, sheetpiling diversion).	Would reduce potential exposure to human and ecological receptors through removal of PCB-containing sediments. Greater removal precision than dredging through the water column and less potential for resuspension and offsite release. May encounter difficulties in achieving low residual PCB concentrations in surface sediments without complete dewatering of river bottom. Potential for PCB release during flooding events. Due to dredging technology limitations, management of post-dredging residuals may be necessary (e.g. through placement of post-dredging cover materials, natural attenuation, or other means) to achieve PCB cleanup goals.	Implementable in areas where site conditions are favorable (e.g., the excavation area can be contained/dewatered and access to sediments is feasible using land-based equipment or equipment in dewatered area). Equipment, materials, and personnel are readily available. Implementability concerns with potential water overtopping, groundwater infiltration and unknown riverbed characteristics. Would require necessary access permissions and would need to meet substantive requirements of applicable regulations. Damage or loss of sensitive habitats may occur where excavation would impact shoreline areas or significantly impact post-removal water levels. Water body and local vicinity use disruptions due to vehicular traffic and equipment activity are implementability considerations	Retained.

Table 2 – Preliminary Screening of Process Options (continued)

Possible General Response Action/ Technology	Process Option	Description	Effectiveness	Implementability	Preliminary Screening
2. Bank Soil					
A. No Action					
No Action	No Action	No remedial measures or monitoring conducted.	Appropriate for areas without significant erosion and/or for areas where PCB levels are not of concern in erodible bank materials. For erodible areas, would not stop continued erosion.	Readily implementable.	Retained per NCP and for comparison to other options.
B. Engineering/Institutional Controls					
Engineering/ Institutional Controls	Physical Access Restrictions	Physical constraints, such as fencing and signs, placed around a bank area containing PCBs to limit access.	Would reduce potential human and ecological exposure to PCBs in bank soil. Could be used during implementation of remedial actions and, in some instances, on a longer-term basis. Would require monitoring and maintenance.	Technically and administratively implementable. Would require property owner(s) agreement.	Retained.
Engineering/ Institutional Controls	Land Use Restrictions	Legal constraints placed on properties to reduce the potential for human exposure to PCBs in bank soil. May include restrictions on future changes to different types of land use (e.g., residential use) and on future activities (e.g., excavation).	Would reduce potential for human exposure to PCB-containing bank soils. Would require monitoring and maintenance.	Technically and administratively implementable. Would require property owner(s) agreement.	Retained.
Engineering/ Institutional Controls	Activity Restrictions on Fishing and/or Hunting	Restrictions, such as catch-and-release fishing restrictions and/or restrictions on certain types of waterfowl hunting, put in place along the Site to prohibit or limit such activities.	Would reduce potential for human exposure to PCBs through ingestion of fish or waterfowl containing PCBs.	Implementable through fishing and hunting regulations and/or license programs. Would require coordination with the appropriate agencies.	Retained.

Table 2 – Preliminary Screening of Process Options (continued)

Possible General Response Action/ Technology	Process Option	Description	Effectiveness	Implementability	Preliminary Screening
B. Engineering/Institutional Controls (Continued)					
Engineering/ Institutional Controls	Consumption Advisories	Advisories established/maintained to limit consumption of certain biota or agricultural products.	Would reduce potential for human exposure by placing restrictions on the consumption of certain biota and agricultural products.	Readily implementable. Commonly used throughout the nation. Would require minimal activities, equipment, and personnel. Would require coordination with appropriate agencies. Would require adequate signage, brochures, etc.	Retained.
Engineering/ Institutional Controls	Pool Elevation Control	Pool elevation controls implemented by the dam owners would minimize the potential for scour, resuspension, and transport of buried PCB-containing sediments.	Would reduce potential exposure of ecological receptors by minimizing the transport of PCB-containing sediment due to scouring and resuspension and the consequent uptake of PCBs by fish and biota. Would assume that the dams and impoundments are operated and maintained by their owners in compliance with applicable laws and regulations prohibiting the exacerbation of existing environmental contamination.	Readily implementable. Dams are currently in place and would require periodic inspection and maintenance.	Retained.
C. Monitored Natural Recovery					
MNR	MNR	Monitoring to confirm that natural physical, chemical, and/or biological processes that are continuing to break down or sequester PCBs in bank soils are continuing to occur.	Would utilize natural processes to reduce potential exposure to human and ecological receptors to PCBs in soil over time. Monitoring would be performed to track effectiveness and rate of recovery.	Readily implementable and minimally intrusive. Activities would be limited to river sampling from a boat and/or shoreline. Access, materials, personnel, and equipment are readily available.	Retained.

Table 2 – Preliminary Screening of Process Options (continued)

Possible General Response Action/ Technology	Process Option	Description	Effectiveness	Implementability	Preliminary Screening
D. *In Situ* Containment					
Capping	Cover (Soil or other materials, including armor layer materials)	Placing cover soil (fill and topsoil) or other materials and/or armoring materials over the PCB-containing bank soil to provide a barrier to prevent direct contact and erosion or disturbance. May require clearing, grubbing and site grading prior to cover placement.	Could significantly reduce potential exposure to human and ecological receptors. Would require post-construction institutional controls and monitoring.	Implementable in most areas. Soil removal may be required prior to placement to achieve stable bank slopes and reduce flow area impingement. Equipment, materials, and personnel are readily available. Would need access permission from property owners.	Retained.
Capping	Engineered Barrier	Placing multiple layers of cover material over the underlying soil. The barrier may include an impermeable layer and may include a combination of sand, gravel, clay, geosynthetics, asphalt and/or topsoil with vegetation planted on the top. Barrier would be designed to isolate and contain underlying soils, prevent direct contact, and minimize potential for PCB migration. May require clearing, grubbing, and site grading prior to barrier placement.	Could significantly reduce potential exposure to human and ecological receptors through isolation of PCB-containing bank soils. Would require institutional controls and long-term monitoring and maintenance.	Implementable in most areas. Soil removal may be required prior to placement to achieve stable bank slopes and reduce flow area impingement. Equipment, materials, and personnel are readily available. Would need access permission from property owners.	Retained.
Rechannelization	Rechannelization	Permanently redirecting a section of the Kalamazoo River into a newly constructed or modified channel, while isolating PCB-containing sediment in the original channel in place (i.e., by covering with clean soil), and restoring the channel to surrounding grade.	Would reduce potential exposure to human and ecological receptors to PCBs by eliminating contact between PCB-containing materials and the river water and human and ecological receptors. Would require long-term monitoring and maintenance as well as deed restrictions related to materials remaining under the cover in the original channel.	Technically implementable in river reaches where property is available and river configuration is conducive to rechannelization (e.g., oxbows). Equipment, materials, and personnel are readily available. Negotiations with potentially affected landowner(s) would be necessary to acquire sufficient tracts of land for rechannelization and to obtain agreements for access.	Retained.

Table 2 – Preliminary Screening of Process Options (continued)

Possible General Response Action/ Technology	Process Option	Description	Effectiveness	Implementability	Preliminary Screening
E. Removal with or without Replacement					
Removal with Replacement	Excavation and Backfilling	Excavating PCB-containing bank soil using conventional earthmoving equipment (e.g., excavators), backfilling excavated areas with clean material, and stabilizing the riverbank using erosion-resistant measures. Dewatering may be required in some locations.	Removal would reduce the amount of PCB-containing material eroding into the river. Would need to replace excavated soil as necessary and would likely require armoring over some backfill areas. May require long-term monitoring and maintenance.	Implementable. Equipment, materials, and personnel are readily available. May be difficult to implement on steep banks, in forest and wetland areas and remote areas not accessible by a serviceable roadway. Would need access permission from property owners.	Retained.
Removal without Replacement	Excavation	Excavating PCB-containing soils using conventional earthmoving equipment (e.g., excavators). Dewatering may be required in some locations.	Would significantly reduce potential exposure to human and ecological receptors through removal of PCB-containing floodplain soils. Lack of replacement of removed materials may alter habitat type or quality.	Implementable. Equipment, materials, and personnel are readily available. May be difficult to implement on steep banks, in forest and wetland areas and remote areas not accessible by a serviceable roadway. Would need access permission from property owners.	Retained.
F. Erosion Control					
Bank Stabilization	Armor Stone	Placing stones on the riverbank to create a barrier against destructive flow or wave action. The size or weight of the armor stone is determined by the flow, wave, or ice forces expected at the location of the structure. May include a geosynthetic separation layer and/or temporary structures to provide a dry work environment and to reduce the potential for dispersing suspended solids.	Could significantly reduce potential erosion through isolation and stabilization of PCB-containing riverbank soils. Would require long-term monitoring and maintenance.	Implementable, but may require some bank soil removal or regrading before placing armor stone. Armor stone can be installed from either land or water, and is adaptable to a wide variety of shoreline conditions. May require a filter layer of gravel or crushed stone to prevent intermixing of bank soil with the armor layer. Equipment, materials, and personnel are readily available. Potential difficulties include work in forest and wetland areas and possible access issues in certain areas.	Retained.

Table 2 – Preliminary Screening of Process Options (continued)

Possible General Response Action/ Technology	Process Option	Description	Effectiveness	Implementability	Preliminary Screening
F. Erosion Control (Continued)					
Bank Stabilization	Revetment Mats	Placing double layers of woven fabric forms filled with concrete or grout, reno mattresses (stone-filled wire baskets), or cellular (cabled) concrete mats on the slope to be protected. The size or weight of the revetment mats would be based on calculated flow, wave, and/or ice forces expected at the location of the bank stabilization structure. Could include an anchoring mechanism to keep the revetment mat in place, a geosynthetic separation layer or gravel filter layer, and/or the placement of a temporary structure to reduce the potential for dispersing suspended solids.	Could significantly reduce potential erosion through isolation and stabilization of PCB-containing riverbank soils. Construction of these measures would temporarily affect vegetation and benthic communities, but impacts would be mitigated over time. Would require long-term monitoring and maintenance.	Implementable, but may require some bank soil removal or regrading before placing revetment mats. Equipment, materials, and personnel are readily available. Potential difficulties include work in forest and wetland areas and possible access issues in certain areas.	Retained.
Bank Stabilization	Retaining Walls	Constructing a retaining wall (e.g., sheetpile, timber, concrete) along the riverbank to stabilize and protect the bank from erosion. Would be designed to create a rigid barrier to earth and water while resisting the lateral pressures imposed by the riverbank soils.	Could significantly reduce potential erosion through isolation of PCB-containing riverbank soils behind the walls. Greatest effectiveness for high, steep banks. Would require long-term monitoring and maintenance.	Implementable. Equipment, materials, and personnel are readily available. May require removal of bank soil located on the river side of the wall. May need to address any associated loss in flood storage capacity or flow area impingement related to installation. Would result in the loss of bank habitat. Other potential difficulties include implementation in forest and wetland areas, possible access issues in certain areas, and potential safety issues depending on the height of the wall.	Retained.

Table 2 – Preliminary Screening of Process Options (continued)

Possible General Response Action/ Technology	Process Option	Description	Effectiveness	Implementability	Preliminary Screening
F. Erosion Control (Continued)					
Bank Stabilization	Gabions	Using mesh containers that are filled with crushed stone to form flexible structures such as retaining walls, seawalls, and channel linings. May include a geosynthetic or gravel separation layer and/or temporary structures to provide a dry work environment and to reduce the potential for dispersing suspended solids. The permeability and flexibility of gabions make them suitable for use where the retained material is likely to be saturated and where the bearing quality of the soil is poor.	Could significantly reduce potential erosion through isolation of PCB-containing riverbank soils. Greatest effectiveness for low, steep banks. Would require long-term monitoring and maintenance.	Implementable. Equipment, materials, and personnel are readily available. Potential difficulties include work in forest and wetland areas and possible access issues in certain areas.	Retained.
Bank Stabilization	Vegetative Cover	Planting appropriate vegetation along the riverbank to stabilize and protect the bank from erosion.	Could reduce potential erosion. Greatest effectiveness for areas not subjected to high shear stresses. Would require long-term monitoring and maintenance.	Technically implementable in certain areas. Maintenance is required to ensure vegetation is established. Equipment, materials, and personnel are readily available. Would need to obtain agreements from property owners.	Retained.

Table 2 – Preliminary Screening of Process Options (continued)

Possible General Response Action/ Technology	Process Option	Description	Effectiveness	Implementability	Preliminary Screening
3. Floodplain Soil					
A. No Action					
No Action	No Action	No remedial measures or monitoring conducted.	Appropriate for areas that already meet cleanup goals, areas where potential human exposure is not reasonably anticipated, and areas where the damages anticipated due to remediation outweigh the potential benefits. No monitoring performed to track effectiveness.	Readily implementable.	Retained per NCP and for comparison to other options.
B. Engineering/Institutional Controls					
Engineering/ Institutional Controls	Physical access Restrictions	Physical constraints, such as fencing and signs, placed around a floodplain area containing PCBs to limit access.	Would reduce potential human and ecological exposure to PCBs in floodplain soil. Could be used during implementation of remedial actions and, in some instances, on a longer-term basis. Would require monitoring and maintenance.	Technically and administratively implementable. Would require property owner agreement.	Retained.
Engineering/ Institutional Controls	Activity Restrictions on Fishing and/or Hunting	Restrictions, such as catch-and-release fishing restrictions and/or restrictions on certain types of waterfowl hunting, put in place along the Site to prohibit or limit such activities.	Would reduce potential for human exposure to PCBs through ingestion of fish or waterfowl containing PCBs.	Implementable through fishing and hunting regulations and/or license programs. Would require coordination with the appropriate agencies.	Retained.

Table 2 – Preliminary Screening of Process Options (continued)

Possible General Response Action/ Technology	Process Option	Description	Effectiveness	Implementability	Preliminary Screening
B. Engineering/Institutional Controls (continued)					
Engineering/ Institutional Controls	Land Use Restrictions	Legal constraints placed on properties to reduce the potential for human exposure to PCBs in floodplain soil. May include restrictions on future changes to different types of land use (e.g., to residential use) and on future activities (e.g., excavation).	Would reduce potential for human exposure to PCB-containing floodplain soils. Would require monitoring and maintenance.	Technically and administratively implementable. Would require property owner agreement.	Retained.
Engineering/ Institutional Controls	Consumption Advisories	Advisories established/maintained to limit consumption of certain biota or agricultural products.	Would reduce potential for human exposure by placing restrictions on the consumption of certain biota and agricultural products.	Readily implementable. Commonly used throughout the nation. Would require minimal activities, equipment, and personnel. Would require coordination with appropriate agencies. Would require adequate signage, brochures, etc.	Retained.
C. Monitored Natural Recovery					
MNR	MNR	Monitoring to confirm that natural physical, chemical, and/or biological processes are continuing to break down or sequester PCBs in floodplain soils.	Would utilize natural processes to reduce potential exposure to human and ecological receptors to PCBs in soil over time. Monitoring would be performed to track effectiveness and rate of recovery.	Readily implementable and minimally intrusive. Activities would be limited to river sampling from a boat and/or shoreline. Access, materials, personnel, and equipment are readily available.	Retained.

Table 2 – Preliminary Screening of Process Options (continued)

Possible General Response Action/ Technology	Process Option	Description	Effectiveness	Implementability	Preliminary Screening
D. *In Situ* Containment					
Capping	Cover (Soil or Pavement)	Placing soil fill and topsoil or pavement over the PCB-containing floodplain soil to provide a barrier to contact. May require clearing, grubbing, and grading prior to cover placement.	Could significantly reduce potential exposure to human and ecological receptors. Would require post-construction institutional controls and monitoring.	Implementable in most areas. Soil removal may be required prior to placement to maintain flood storage. Equipment, materials, and personnel are readily available. Would need access permission from property owners. May not be compatible with current or future uses of floodplain. May create flood storage issues due to volume expansion.	Retained.
Capping	Engineered Barrier	Placing multiple layers of cover material over the underlying soil. The barrier may include an impermeable layer and may also include a combination of sand, gravel, clay, geosynthetics, asphalt, and/or topsoil with vegetation planted on the top. Barrier would be designed to isolate and contain underlying soils, prevent direct contact, and minimize potential for PCB migration. May require clearing, grubbing, and site grading prior to barrier placement.	Could significantly reduce potential exposure to human and ecological receptors through isolation of PCB-containing floodplain soils. Would require institutional controls and long-term monitoring and maintenance.	Implementable in most areas. Soil removal may be required prior to placement to maintain flood storage. Equipment, materials, and personnel are readily available. Would need access permission from property owners. May not be compatible with current or future uses of floodplain. May create flood storage issues due to volume expansion.	Retained.

Table 2 – Preliminary Screening of Process Options (continued)

Possible General Response Action/ Technology	Process Option	Description	Effectiveness	Implementability	Preliminary Screening
E. Restoration-Based Remediation					
Restoration-Based Remediation	Soil cover, soil amendments, or phyto-remediation.	Placing or mixing soil, soil amendments, or fertility agents in the floodplain areas to promote reduction of PCB bioavailability, exposure, mobility, or toxicity in floodplain soils in conjunction with improving the fertility and growth of vegetation and desirable habitats. May require clearing, grubbing, and site grading prior to cover placement or amendment mixing.	Could significantly reduce potential exposure to human and ecological receptors. Ongoing research may support implementation of phyto-remediation approaches. May require post-construction institutional controls and monitoring.	Implementable in most areas. Soil removal may be required prior to placement to maintain flood storage. Equipment, materials, and personnel are readily available. Would need access permission from property owners. May not be compatible with current or future uses of floodplain.	Retained
F. Removal with and without Replacement					
Removal with Replacement	Excavation and Backfilling	Excavating PCB-containing floodplain soil using conventional earthmoving equipment (e.g., excavators) and backfilling the excavated area with clean material. Dewatering may be required in some locations.	Would significantly reduce potential exposure to human and ecological receptors through removal of PCB-containing floodplain soils. Would need to replace excavated soil as necessary. May require long-term monitoring and maintenance.	Implementable in most areas. Equipment, materials, and personnel are readily available. May be difficult to implement in forest and wetland areas and remote areas not accessible by a serviceable roadway. Would need access permission from property owners.	Retained.
Removal without Replacement	Excavation	Excavating PCB-containing floodplain soil using conventional earthmoving equipment (e.g., excavators). Dewatering may be required in some locations.	Would significantly reduce potential exposure to human and ecological receptors through removal of PCB-containing floodplain soils. Lack of replacement of removed materials may alter habitat type or quality. May require long-term monitoring and maintenance.	Implementable in most areas. Equipment, materials, and personnel are readily available. May be difficult to implement in forest and wetland areas and remote areas not accessible by serviceable roadway. Would need access permission from property owners.	Retained.

Table 2 – Preliminary Screening of Process Options (continued)

Possible General Response Action/ Technology	Process Option	Description	Effectiveness	Implementability	Preliminary Screening
G. Erosion Control					
Erosion Control	Revetment Mats	Placing double layers of woven fabric forms filled with concrete or grout, reno mattresses (stone-filled wire baskets), or cellular (cabled) concrete mats in slope areas to be protected within the floodplains. Could include an anchoring mechanism to keep the revetment mat in place, a geosynthetic separation layer or gravel filter layer, and/or the placement of a temporary structure to reduce the potential for dispersing suspended solids.	Could significantly reduce potential erosion through isolation of PCB-containing soils. Construction of these measures would temporarily affect vegetation and benthic communities, but impacts would be mitigated over time. Would require long-term monitoring and maintenance.	Implementable, but may require some soil removal before placing revetment mats. Equipment, materials, and personnel are readily available. Potential difficulties include work in forest and wetland areas and possible access issues in certain areas.	Retained.
Erosion Control	Vegetation Covers	Planting appropriate vegetation on floodplains to stabilize and protect the floodplain soils from erosion.	Could reduce potential erosion. Would require long-term monitoring and maintenance.	Technically implementable. Maintenance is required to ensure vegetation is established. Equipment, materials, and personnel are readily available. Would need to obtain agreements from property owners.	Retained.

Table 2 – Preliminary Screening of Process Options (continued)

Possible General Response Action/ Technology	Process Option	Description	Effectiveness	Implementability	Preliminary Screening
4. Management of Dredged or Excavated Material					
A. Solids Dewatering (primarily applicable to dredged material)					
Mechanical	Belt Filter Press	Slurry drops onto a perforated belt where gravity drainage takes place. Thickened solids are pressed between a series of rollers to further dewater solids.	Reliable. May require pretreatment to enhance dewatering.	Implementable. Equipment, materials, and operating personnel are available. Would require treatability testing prior to implementation.	Retained.
Mechanical	Plate and Frame Filter Press	Slurry is pumped into cavities formed by a series of plates covered by a filter cloth. Liquids are forced through filter cloth and dewatered solids are collected in the filter cavities.	Reliable. May require pretreatment to enhance dewatering. Generally, plate and frame presses achieve lower water contents in cake solids than belt filter presses.	Implementable. Equipment, materials, and operating personnel are available. Would require treatability testing prior to implementation.	Retained.
Mechanical	Solid Bowl (Centrifuge)	Slurry is fed through a central pipe that sprays into a rotating bowl. Centrate discharges out of the large end of the bowl and solids are removed from tapered end of the bowl by means of a screw conveyer.	Historically, process has required frequent maintenance and often experienced operational difficulties. Cake solids are typically lower than those attained by filter presses.	Implementable for certain types of sediments. Centrifuge operation is not efficient when feed composition is variable. Equipment, materials, and operating personnel are available.	Not retained. The variability of sediment/soil composition could make this process difficult to control, and it produces lower cake solids than other options.
Mechanical	Evaporator	Excess water is evaporated from slurry.	Reliable. May require pretreatment to enhance dewatering.	Potentially implementable, but likely not practical. May produce drier cake than required, and has higher cost than other mechanical dewatering options. Not usually employed for sediments.	Not retained due to higher energy requirement and higher cost than other dewatering process options.

Table 2 – Preliminary Screening of Process Options (continued)

Possible General Response Action/ Technology	Process Option	Description	Effectiveness	Implementability	Preliminary Screening
A. Solids Dewatering (primarily applicable to dredged material) (Continued)					
Gravity Settling	Stockpile	Material is placed in a stockpile, and free liquids are allowed to drain off and are collected.	Reliable. Effectiveness primarily applies to mechanically dredged sediments.	Implementable. Equipment, materials, and operating personnel are readily available. Would require adequate space for dewatering structures.	Retained.
Gravity Settling	Thickener	Slurry enters thickener and settles into circular tank. Sediment thickens and consolidates at the bottom of the tank. Pretreatment with chemical addition used to enhance settling.	Effectiveness primarily limited to hydraulically dredged sediments. May be effective when used as a pretreatment step in conjunction with other dewatering technologies. A Site-specific study would be required to verify effectiveness.	Implementable. Equipment, materials, and operating personnel are available. Would require adequate space for dewatering structures.	Retained.
Gravity Settling	Settling Basin	Slurry enters settling basin and is allowed to settle, drain, and consolidate in bottom of basin. Pretreatment with chemical addition may be used to enhance settling.	Effectiveness primarily limited to hydraulically dredged sediments. May be effective when used as a pretreatment step in conjunction with other dewatering technologies. A Site-specific study would be required to verify effectiveness.	Implementable. Equipment, materials, and operating personnel are readily available. Would require adequate space for dewatering structures.	Retained.
Gravity Settling	GeoTubes	Slurry is pumped into fabric tubes, and solids consolidate as liquids are forced out. The liquids are collected, and the consolidated solids are removed from the tubes for subsequent management. Polymer addition is a critical component.	Effectiveness primarily limited to hydraulically dredged sediments. A Site-specific study would be required to verify effectiveness. System has been used for hydraulically dredged sediments with PCBs from the Fox River and Grasse River, but drying issues have been noted.	Implementable. Equipment, materials, and operating personnel are available. Would require adequate space for dewatering structures.	Retained.

Table 2 – Preliminary Screening of Process Options (continued)

Possible General Response Action/ Technology	Process Option	Description	Effectiveness	Implementability	Preliminary Screening
B. Stormwater Management					
Collection and Treatment	Collection and Treatment	Collect stormwater that comes in contact with PCB-containing soil/sediment. Collected water would be treated onsite or offsite or directly discharged back into the river, whichever is selected as the water treatment process option.	Reliable. Would not require long-term operations and maintenance.	Implementable. Equipment, materials, and operating personnel are available.	Retained.
Diversion	Diversion	Divert stormwater away from PCB-containing soil/sediment. Some pretreatment may be necessary to remove solids.	Reliable. Would not require long-term operations and maintenance.	Implementable. Equipment, materials, and operating personnel are available. Requires adequate space and topography for effective drainage.	Retained.
C. Process Water Management					
Treatment	Onsite Treatment Plant	Process water is pumped to a water treatment plant constructed onsite and treated to meet discharge requirements.	Reliable. Already implemented at the Site during previous and ongoing remedial activities. Would be effective for permanent removal of PCBs from water. Would not require long-term operations and maintenance.	Implementable. Equipment, materials, and operating personnel are available. Would require adequate space for treatment equipment.	Retained.
Treatment	Offsite Treatment Plant	Process water is transported to a water treatment plant offsite and treated to meet discharge requirements.	Reliable. Would be effective for permanent removal of PCBs from water. Risks of exposure and transportation accidents increase with significantly increased haul distances. Would not require long-term operations and maintenance.	Implementable. Equipment, materials, and operating personnel are available. Would require adequate space for treatment equipment.	Retained.

Table 2 – Preliminary Screening of Process Options (continued)

Possible General Response Action/ Technology	Process Option	Description	Effectiveness	Implementability	Preliminary Screening
D. *Ex Situ* Treatment					
Physical	*Ex Situ* Stabilization/ Solidification	Mixing the removed materials *ex situ* with Portland cement, fly ash, lime, kiln dust, or some other stabilization agent. May be used for dewatering only, to reduce the leachability (i.e., mobility) of the chemical constituents, or to modify the material's structural properties.	Would reduce the mobility and toxicity of PCBs but would increase disposal volume because of addition of stabilization agents. Commonly used to reduce free moisture for disposal purposes, and can be used to reduce chemical constituent toxicity and mobility. Would not require long-term operation and maintenance.	Implementable. Equipment, materials, and operating personnel are available. Would require sufficient space to conduct the treatment and processing activities, as well as agreement with the relevant property owner.	Retained.
Physical	Particle Separation	Physically separating the finer-grained PCB-containing particulates for subsequent management and treatment through particle size separation techniques (e.g, soil washing).	Effectiveness depends on association between PCBs and grain size. Could reduce the volume of material requiring treatment/disposal. Treatability testing would be necessary to evaluate effectiveness for Site sediments/soils. Would not require long-term operation and maintenance.	Implementable, but would require specialized equipment and materials. Operating personnel are likely readily available. Would require sufficient space to conduct the treatment and processing activities, as well as agreement with the relevant property owner.	Retained.

Table 2 – Preliminary Screening of Process Options (continued)

Possible General Response Action/ Technology	Process Option	Description	Effectiveness	Implementability	Preliminary Screening
D. *Ex Situ* Treatment (Continued)					
Chemical	Chemical Extraction	An extraction fluid/solvent is mixed with the sediment/soil, and PCBs are removed from the solid media into the extracting fluid. Extracting fluid is used to desorb solid-phase PCBs from the solids matrix.	Could be applied to dredged sediments and/or soils to reduce toxicity, mobility, and volume of PCBs prior to disposal. Has been used at other sites to reduce PCB concentrations. May require pretreatment prior to implementation. Effectiveness is dependent on sediment/soil type, grain size, water content, organic content, and physico-chemical properties of the chemicals present. Treatability testing would thus be warranted, at least prior to implementation, to select most effective technique for the Site. Would not require long-term operation and maintenance.	Implementable, but would require specialized equipment, materials, and operating personnel. Concentrated PCBs in the extract would require proper disposal. Traces of chemical/solvent remaining in the treated solids may need to be addressed, depending on the end use of the treated materials. Would require sufficient space to conduct the treatment and processing activities as well as an agreement with a property owner.	Retained.
Chemical	Chemical Destruction	Adding reagents to the sediment/soil to break down the PCBs. Destruction process can be achieved through several processes including base-catalyzed dechlorination, gas-phased reduction, and sodium-based degradation.	Not proven effective on a full-scale basis at sites with PCB-containing sediment and soil. Variability of sediment/soil composition and PCB content could make this process difficult to control. Would not require long-term operation and maintenance.	Implementability is questionable. No full-scale applications of this process option were identified that have successfully destroyed PCBs at concentrations similar to those at the Site. Would require specialized equipment, materials, and operating personnel. Would require sufficient space to conduct the treatment and processing activities as well as an agreement with a property owner.	Not retained because this process has not been proven effective at full scale for materials similar to Site sediments and soils, and the variability of sediment/soil composition and PCB content at this site could make this process difficult to control.

Table 2 – Preliminary Screening of Process Options (continued)

Possible General Response Action/ Technology	Process Option	Description	Effectiveness	Implementability	Preliminary Screening
D. *Ex Situ* Treatment (Continued)					
Thermal	Thermal Desorption	Physically separating PCBs from the sediment/soil by adding heat to volatilize the PCBs. Volatilized PCBs are then condensed/ collected as a liquid, captured on activated carbon, and destroyed in an afterburner.	Would reduce the potential toxicity, mobility, and volume of PCBs in the removed solids via treatment and proper management and/or disposal of treatment residuals. Would require appropriate environmental and process controls. Depending on effectiveness, could be evaluated for use in reducing PCB concentrations in removed materials to levels that may allow more cost-effective disposal options or possibly reuse of treated materials as backfill. Treatability tests using sediments/soils from representative reaches of the Kalamazoo River may be warranted to evaluate degree of effectiveness and reuse potential of treated solids. Would not require long-term operation and maintenance.	Potentially implementable. Would require specialized equipment, materials, and operating personnel; commercial vendors are available. May require stabilization and/or dewatering before treatment. Would require an additional step to destroy the removed chemicals. Would require sufficient space to conduct the treatment and processing activities, as well as an agreement with a property owner. Thermal treatment units at other sites have often been met with community resistance (e.g., New Bedford Harbor).	Retained.

Table 2 – Preliminary Screening of Process Options (continued)

Possible General Response Action/ Technology	Process Option	Description	Effectiveness	Implementability	Preliminary Screening
D. *Ex Situ* Treatment (Continued)					
Thermal	Thermal Destruction	Using heat to destroy the organic compounds (i.e., PCBs) present in removed sediment/soil.	Would reduce the potential toxicity, mobility, and volume of PCBs in the removed solids via destruction of the PCBs with subsequent disposal of treatment residuals. Would require appropriate environmental and process controls. Would not require long-term operation and maintenance.	Potentially implementable but not practical. Would require specialized equipment, materials, and operating personnel. May require stabilization and/or dewatering before treatment. Would require sufficient space to conduct the treatment and processing activities as well as an agreement with a property owner. Option has encountered strong community opposition at other sites (e.g., New Bedford Harbor). May encounter significant administrative constraints in securing necessary access agreements and meeting the substantive requirements of applicable regulations. More costly than thermal desorption.	Not retained due to: 1) likely community acceptance issues; 2) administrative and regulatory constraints; and 3) higher costs and lack of additional benefits compared to thermal desorption.
E. Transportation					
Barge	Barge	Transporting removed sediment/soils to appropriate treatment/disposal facility via barge. May require stabilization or dewatering before transportation.	Reliable.	Implementable if access is adequate (i.e., sufficient water depth for barge operation; usable riverbank in proximity). May only be implementable at certain areas of the Site.	Retained.
Truck	Truck	Transporting removed sediment/soils to appropriate treatment/disposal facility via truck. May require stabilization or dewatering before transportation.	Reliable.	Implementable as long as there is an appropriate number of permitted trucks with the necessary availability and capacity.	Retained.
Rail	Rail	Transporting removed sediment/soils to appropriate treatment/disposal facility via rail. May require stabilization or dewatering before transportation.	Reliable.	Implementable if access or proximity to rail transport is adequate. Equipment (e.g., track) may not be readily available. Would need access permission from property owners. May only be implementable at certain areas of the Site.	Retained.

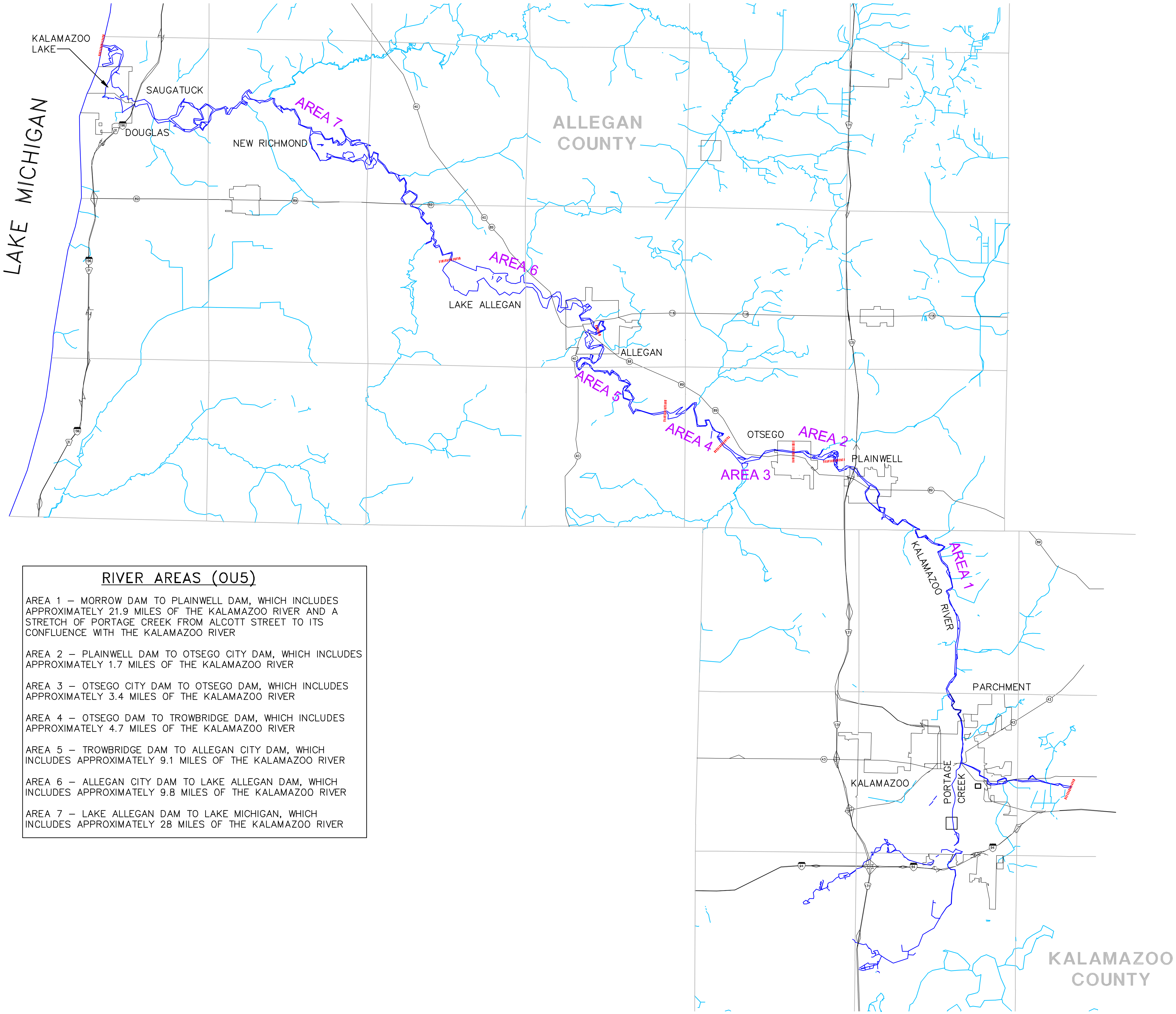
Table 2 – Preliminary Screening of Process Options (continued)

Possible General Response Action/ Technology	Process Option	Description	Effectiveness	Implementability	Preliminary Screening
E. Transportation (Continued)					
Pipeline	Pipeline	Transporting hydraulically dredged sediment/soils to appropriate treatment/disposal facility via pipeline.	Reliable.	Implementable. Equipment, materials, and operating personnel are readily available. Would need access permission from property owners.	Retained.
F. Disposal					
Confined Disposal Facility (CDF)	In-water CDF or Confined Aquatic Disposal (CAD)	Placing PCB-containing sediment/soil in a disposal facility constructed within a water body to permanently isolate PCB-containing material.	Could effectively manage PCB-containing sediments/soils. May result in loss of aquatic habitat. Would require long-term monitoring and maintenance.	Implementable so long as suitable in-water location is identified where CDF or CAD could be constructed and transport for disposal of sediments is feasible and which would meet applicable substantive regulatory requirements. Equipment, materials, and operating personnel are available.	Retained.
CDF	On-land CDF	Placing PCB-containing sediment/soil in an on-land CDF or upland disposal facility constructed in close proximity to the Site, following dewatering where necessary. The CDF may be designed to receive removed sediment or soil from one or more Areas of the Site.	Could effectively manage PCB-containing soils/sediments, thereby preventing future exposure of human and ecological receptors to the removed material. Disposal in close proximity to the Site would preclude the need to transport large volumes of sediment over long distances to an offsite disposal facility(ies), thereby reducing or eliminating the potential for accidents and spills during offsite transport. Depending on the location of the facility, construction could potentially result in the loss of habitat. Would require long-term operation, monitoring, and maintenance.	Implementable if a suitable location is identified that would meet applicable substantive regulatory requirements (or if a waiver could be obtained). Equipment, materials, and operating personnel are available.	Retained.

Table 2 – Preliminary Screening of Process Options (continued)

Possible General Response Action/ Technology	Process Option	Description	Effectiveness	Implementability	Preliminary Screening
F. Disposal (continued)					
Offsite Disposal	Offsite Permitted Facility	Transporting excavated sediment/soils to appropriate offsite disposal facility(ies) – TSCA facility for TSCA-regulated materials, permitted solid waste facility for other materials. May require stabilization or dewatering before offsite transport and disposal.	Would be effective for permanent disposition of removed sediment/soil. Risks of exposure and transportation accidents increase with significantly increased haul distances of materials.	Implementable so long as there are appropriate permitted offsite facility (ies) with the necessary availability and capacity, and an adequate means of transport is available.	Retained.
Beneficial Reuse	Beneficial Reuse	Using treated material in beneficial ways, such as cover material for solid waste landfills, or converting it into useable products such as cement, lightweight aggregate, or glass tile.	Would be effective for permanent placement of treated soil /sediment.	Implementable, but may require specialized equipment and materials. Operating personnel are likely readily available. Would need to confirm viable cost-effective uses (e.g., potential markets).	Not retained. To date, few dredged sediment sites have applied beneficial reuse, mainly due to the lack of cost-effective uses. No sites have been identified where a full-scale beneficial reuse technology was successfully applied to manage sediments or soils with PCB concentrations comparable to those at the Site.

Figure



NOTES:

1. ALLEGAN AND KALAMAZOO COUNTY MAPPING OBTAINED FROM MICHIGAN RESOURCE INFORMATION SYSTEM.

LEGEND:

LIMITS OF RIVER AREAS WITHIN OU5

RIVER AREAS (OU5)

AREA 1 – MORROW DAM TO PLAINWELL DAM, WHICH INCLUDES APPROXIMATELY 21.9 MILES OF THE KALAMAZOO RIVER AND A STRETCH OF PORTAGE CREEK FROM ALCOTT STREET TO ITS CONFLUENCE WITH THE KALAMAZOO RIVER

AREA 2 – PLAINWELL DAM TO OTSEGO CITY DAM, WHICH INCLUDES APPROXIMATELY 1.7 MILES OF THE KALAMAZOO RIVER

AREA 3 – OTSEGO CITY DAM TO OTSEGO DAM, WHICH INCLUDES APPROXIMATELY 3.4 MILES OF THE KALAMAZOO RIVER

AREA 4 – OTSEGO DAM TO TROWBRIDGE DAM, WHICH INCLUDES APPROXIMATELY 4.7 MILES OF THE KALAMAZOO RIVER

AREA 5 – TROWBRIDGE DAM TO ALLEGAN CITY DAM, WHICH INCLUDES APPROXIMATELY 9.1 MILES OF THE KALAMAZOO RIVER

AREA 6 – ALLEGAN CITY DAM TO LAKE ALLEGAN DAM, WHICH INCLUDES APPROXIMATELY 9.8 MILES OF THE KALAMAZOO RIVER

AREA 7 – LAKE ALLEGAN DAM TO LAKE MICHIGAN, WHICH INCLUDES APPROXIMATELY 28 MILES OF THE KALAMAZOO RIVER

KALAMAZOO RIVER STUDY GROUP
ALLIED PAPER, INC./PORTAGE CREEK/KALAMAZOO RIVER
SUPERFUND SITE
MULTI-AREA FEASIBILITY STUDY
TECHNICAL MEMORANDUM

AREAS OF THE SITE

ARCADIS

FIGURE
1